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UTILIZATION OF CALIFORNIA FRUITS

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FOR A NUMBER OF YEARS, the markets have not been able to absorb the supply of most kinds of California fruits at prices that are profitable to the grower, and frequently large surpluses have been allowed to go to waste. The causes for this situation are several, among which may be mentioned overplanting stimulated by post-War high prices; increased competition with fruits and fruit products of other regions, for example, pineapple products; decreased buying power of consumers owing to the depression; and changing fruit food habits, for example, use of certain fruit juices instead of certain other canned or stewed fruits. Because of this situation the California Agricultural Experiment Station receives numerous requests for information and advice concerning utilization of surplus fruits. The present circular has been prepared to answer such requests.

It has been stated that foods are competitive for a place on the table and in the human stomach. Human intake of food, expressed on the calorie basis, is rather inelastic, other things being equal. Yet, the per-capita consumption of fruits of all kinds expressed upon the fresh basis is only about 206 pounds a year,[3] or about 3.7 per cent of the total food intake per capita on a calorie basis, assuming an average value of fruits on the fresh basis of 200 calories per pound and an average total requirement of 3,000 calories per day per person.[4] It would seem that American consumers could use more fruits without seriously upsetting the economy of staple foods, such as cereal products, dairy products, sugars, and meats.

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[3] Shear, S. W. Deciduous fruit statistics. University of California Giannini Foundation Mimeo. Rept. 69:16. 1940.
[4] Atwater, A. O. Principles of nutrition and nutritive value of food. U. S. Dept. Agr. Farmers' Bul. 142:1–48. 1902.

The present circular is based largely upon the results of investigations made at this station during the past twenty-five years. The information is presented according to products, such as unfermented beverages and sieved fruits, rather than according to the different varieties of fruits.

References.—Most of the journal articles cited in this circular can be consulted in any well-equipped library. This station does not have these articles for distribution. The bulletins of various agricultural experiment stations can be obtained from the stations issuing them, sometimes for a small charge if the publications are not out of print. If they are out of print, they may be consulted in the bound volumes in many of the larger libraries. The available United States Department of Agriculture publications can be had for small sums in coin or money order (stamps are not accepted) from the Superintendent of Documents, Washington, D. C. Those that are out of print will be found in bound sets in libraries. We have attempted to indicate the various station and United States Department of Agriculture publications out of print at the time this circular goes to press.

PRESENT DISPOSAL OF CALIFORNIA FRUITS

Shear (see footnote 3, p. 1) has prepared the statistics given in table 1 to indicate in a general manner the present outlets for California fruits.

The total quantity of oranges used commercially for processed products, according to Shear, was 126,238 tons a year for the period 1934–1938. About 25,000 tons of this total are canned as juice, the average for the period in question being about 750,000 cases annually. A considerable tonnage is utilized for bottler's sirups, orange concentrate, and dairy-base sirups. Some oranges are used for essential oil and for dried stock feed. An unknown quantity is not utilized in any manner and is dumped on the cull heaps in the citrus areas. The above uses comprise a relatively small proportion of the total orange production. It must be remembered, however, that a very large proportion, probably more than 50 per cent, of the oranges sold fresh are used in juice stands, restaurants, in the home, and elsewhere, for juice consumed fresh.

Grapes designated "otherwise processed" in table 1 are those crushed commercially for wine. Practically all of the wine grapes shipped fresh, namely, 161,960 tons annually for the 1934–1938 period, were utilized for the making of wine in the home. Most of the table and raisin grapes "otherwise processed" were crushed for wine.

Most of the apples "otherwise processed" were utilized for fresh juice and vinegar, small amounts being utilized for hard cider, brandy, apple wine, boiled cider, and apple butter.

Most of the 11,025 tons of cherries "otherwise processed" were barreled in brine containing sulfur dioxide and lime. These were utilized for preparation of Maraschino cherries, principally for addition to canned fruits for salad and canned fruit cocktail.

With the exception of 1939, all of the apricots grown were harvested; Shear estimates that about 9,000 tons were not picked in 1939.

TABLE 1*

Harvested Production and Utilization of California Fruits on a Fresh Basis; Average 1934–1938

Kind of fruit	Harvested	Dried	Canned (other than orange juice)	Otherwise processed	Used as fresh fruit
	tons	*tons*	*tons*	*tons*	*tons*
Total fruits	5,558,880	1,875,868	399,953	943,756	2,339,303
Deciduous, total	3,941,752	1,875,868	399,953	757,523	908,408
Grapes, total	2,118,600	881,520	4,060	736,800	496,220
Deciduous tree, total	1,823,152	994,348	395,893	20,723	412,188
Citrus, total	1,617,128	0	0	186,233	1,430,895
Deciduous tree:					
Apples	206,592	72,648	528	14,808	118,608
Apricots	216,000	143,640	54,320	0	18,040
Cherries	20,360	0	3,420	5,915	11,025
Figs	86,900	76,260	5,025	0	5,615
Peaches	482,400	139,300	265,060	0	78,040
Pears	219,800	32,000	65,700	0	122,100
Plums	60,600	0	1,840	0	58,760
Prunes	530,500	530,500	0	0	0
Grapes:					
Wine	558,200	960	0	395,280	161,960
Table	371,600	6,160	0	160,920	204,520
Raisin	1,188,800	874,400	4,060	180,600	129,740
Citrus:					
Oranges	1,237,761	0	0	126,238	1,111,523
Lemons	325,037	0	0	55,723	269,314
Grapefruit	64,330	0	0	4,272	50,058

* From: Shear, S. W. Deciduous fruit statistics. University of California Giannini Foundation Mimeo. Rept. **69**:6. 1940.

A large proportion of the figs after drying were converted into dried fig paste for use by bakers, confectioners, and cracker manufacturers.

Of the total fig production, about 5,900 tons on the dry basis, or about 20 per cent of the crop, was unmerchantable each year. Most of this was unfit for human consumption and was used for stock food.

Most of the freestone peaches were harvested each year and utilized for drying, canning, and fresh sale; but in 1938 about 21,000 tons and in 1939 about 9,000 tons of clingstone peaches were not utilized. In 1935, 1936, and 1937, all of the clings were harvested. An average of about 35,900 tons of clings were dried each year.

All of the Bartlett pear crop was harvested in 1935 and 1936. In 1937 about 10,000 tons, in 1938 about 20,000 tons, and in 1939 about 5,000 tons of Bartlett pears were not harvested.

Similar data for other fruits are difficult to secure or to estimate. The production of most California fruits at present, however, is in excess of the quantity that can be marketed at reasonable profit under existing economic and world political conditions.

UNFERMENTED BEVERAGES

One of the most important outlets for certain fruits is their use in various unfermented beverages. These are chiefly fresh, canned, and bottled juices, bottled carbonated beverages (fruit soda waters), so-called "dairy-base beverages," beverages made from dried fruits, and fountain beverages. The dairy and fountain beverages are prepared from sirups and concentrates.

In view of the continued increase in consumption of unfermented fruit juices, they should utilize an increasing proportion of the surplus of certain fruits.

Fresh Juices.—Practically all lemons and limes sold fresh are used for the preparation of lemonade and limeade, or added in the fresh condition to various mixed beverages. Much of the orange crop is used in the home or in juice stands, restaurants, hotels, hospitals, and other establishments, for preparing juice for immediate consumption in the fresh state. Many thousands of tons of apples are crushed and pressed for juice sold fresh.

Freshly prepared juices are superior in flavor and aroma to those preserved in any manner. The principal obstacles to increased use of fresh juices lie in cost of transportation of fresh fruits to distant centers of population; the relatively short season for some fruits; and, except for citrus fruits, the high cost and large size of equipment required for extracting the juice.

If inexpensive, simple, small-sized, easily cleaned devices for extracting apple, grape, and berry juices were made available and popularized for home and juice-stand use, it is likely that consumption of the fresh juices could be increased materially. The growers' associations have popularized such devices for preparation of citrus juices with very great benefit to their industry. This fact is of particularly great importance

to the growers and shippers of Washington Navel oranges; for the juice of this fruit has proved, to date, unsuitable for canning or bottling, owing to its strong tendency to undergo rapid adverse changes in flavor and quality after extraction.

In Europe fresh grapes and fresh grape juice are used in important quantities in the so-called "grape cure." That is, many of those suffering from digestive disturbances, nervous disorders, alcoholism, or certain other ailments go to the grape districts and for a period of several weeks live chiefly on fresh grapes and grape juice. It is specified that the juice must be consumed immediately after pressing, a recommendation supported by scientific evidence that vitamin C is very rapidly oxidized in fresh juice and that vitamin B_1 decreases rather rapidly on standing of the juice. The grape cure seems to have some scientific basis since most of the ailments treated by it are due to B_1 deficiency.

Perhaps American producers and shippers of fresh grapes could introduce this European custom to America with advantage.[5] But, it would probably be necessary to secure further experimental evidence on the dietary value of grapes. They are known to be a fair source of vitamin B_1, a good source of G (riboflavin), and to exert a strongly basic reaction in the system.

While orange, apple, and grape juices probably will remain for some time to come the most important of juices for fresh use, it is possible that pomegranate, Logan and Boysen blackberries, and certain other fruits might attain some favor for this purpose.

Bottled Juices.—Since the bottling of juices is thoroughly covered in Circular 344 of this station[6] and in other publications, it will be presented only very briefly here.

Grape juice will be considered first and the other bottled juices compared with it. California packs very little grape juice, because of the scarcity of the Concord and other eastern juice varieties. The investigations of this station, however, show that a desirable juice can be made from California vinifera grapes.

The preparation of grape juice in the eastern United States is described by Tressler, Joslyn, and Marsh,[7] and by Tressler and Pederson,[8] to whose publications the reader is referred for details.

Based upon the investigations made by this station, the procedure recommended in Circular 344 is suggested for the preparation of bottled

[5] Anonymous. Fruit juice for heart disease. Food Industries 12(2):95. 1940.

[6] Joslyn, M. A., and G. L. Marsh. Utilization of fruit in commercial production of fruit juices. California Agr. Exp. Sta. Cir. 344:1–63. 1937.

[7] Tressler, D. K., M. A. Joslyn, and G. L. Marsh. Fruit and vegetable juices. xii + 549 p. Avi Publishing Co., Inc., New York, N. Y. 1938.

[8] Tressler, D. K., and C. S. Pederson. Preservation of grape juice. II. Factors affecting the rate of deterioration of bottled Concord juice. Food Research 1:87–97. 1936.

white and bottled red juices from California grapes. Additional details are given in some less readily available publications.[9]

Bottled apple juice is usually brilliantly clear, a condition that requires special treatment. The apples used should be of rich flavor and tart. The Winesap, Stayman Winesap, and Spitzenburg (Esopus Spitzenburg) have proved satisfactory in our tests.[10] If picked at the proper stage of maturity, the Gravenstein gives a pleasing juice. The Yellow

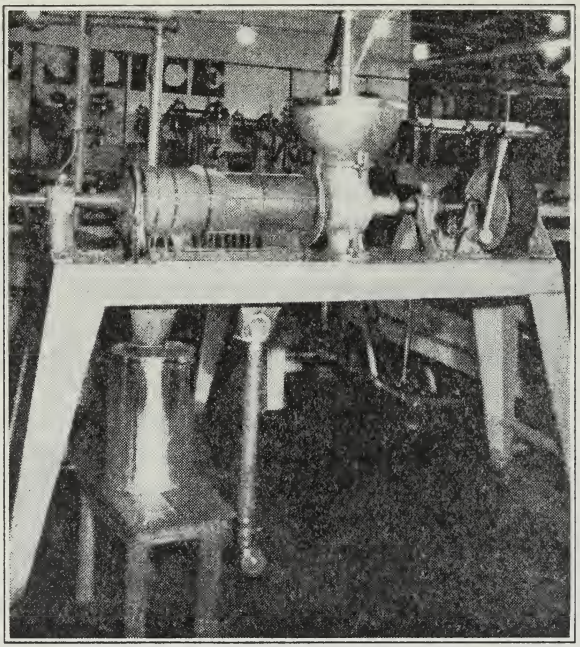

Fig. 1.—A continuous juice extractor. (Courtesy of American Utensil Co., Food Industries photograph.)

Newtown is also of fair quality for juice. The procedure described in Circular 344 (see footnote 6, p. 5) is recommended.

Logan and Boysen blackberry and other berry juices may be packed as described in Circular 344. These juices should be sweetened before bottling in order to retain their fresh flavor. They are diluted with water at the time of serving. Figure 1 illustrates a suitable juice extractor.

[9] Cruess, W. V. Unfermented fruit juices. California Agr. Exp. Sta. Cir. 220:1–32. 1920. (Out of print; replaced by Circular 344, cited in footnote 6.)

Cruess, W. V., and J. H. Irish. Fruit beverage investigations. California Agr. Exp. Sta. Bul. 359:526–68. 1923. (Out of print.)

Cruess, W. V., and L. Cash. Canning of California grape juice. Fruit Products Journal 15:357–58, 364, 373. 1936.

[10] Celmer, R. E., and W. V. Cruess. Experiments on the canning of apple juice. Fruit Products Journal 16:356–59, 379. 1937.

Circular 344 discusses the problems of flavor retention in citrus juices and describes modern procedure based largely on the research of this station.

Pomegranates yield a very good juice useful in mixing with other juices. At present there is practically no market for this fruit. See Circular 344 for procedure.

The utilization of surplus prunes is at present the most serious economic problem in California fruit industries. Our recent studies have developed a procedure that gives a beverage of superior flavor. As this process is not given in Circular 344, it is presented briefly here.

Prunes of the present or last season's crop and of superior quality must be used. Small inferior prunes are fit only for stock feed. The prunes are covered with water, heated to 175°–190° F and allowed to stand 8–24 hours. The liquid is then drawn off and the extraction repeated with fresh water. In practice, three tanks would be operated in a series as a diffusion battery and a single extract instead of three would be obtained, as in extracting sugar from beets. The extracts are mixed and diluted to 20° Balling with water, and citric acid added to taste. It is heated to 175° F, bottled, sealed, and cooled. Under the food and drug regulations, the product may not be termed a "juice." It may be called "prune beverage" qualified by the words, "an extract of dried prunes."

Plum juice, made from red or black or purple plums, or a mixture of one of these with white plums, is pleasing in flavor and appearance. Addition of sugar is usually necessary as with berry juices.

Peaches, pears, apricots, and certain other fruits do not give undiluted juices suitable for bottling; but pulpy bottled beverages may be made as described in Circular 344.

Canned Fruit Juices.—In recent years the canning of fruit juices has attained great importance, and now utilizes a considerable proportion of the pineapples of Hawaii, the grapefruit of Florida and Texas, and the oranges of California and Florida. We believe that canned apple juice and canned beverages made from prunes and from apricots are sufficiently pleasing in flavor and appearance and of such high dietary value that they have the possibility of attaining great popularity.

The canning of these and other fruit juices is presented quite fully in Circular 344 (cited in footnote 6, p. 5). The following additional comments may, however, be helpful.

Gravenstein apples yield an excellent canned juice if the fruit is allowed to reach full flavor on the tree and is not picked at the immature stage customary for the fruit for eastern shipment. For best results the

juice of the Yellow Newtown should be blended with that of a variety of higher acidity and flavor such as the Winesap, Stayman Winesap, or Baldwin. All apple juices rapidly lose their flavor and aroma in plain tin cans; on the other hand, reënameled type-L cans, or cans lined with so-called "apple-juice enamel" retain these qualities almost perfectly. This station was the first to establish the fact that enamel-lined cans are necessary for the retention of flavor in apple juice. (See footnotes 9 and 10, p. 6.)

In preparing canned prune beverage—that is, water extract of dried

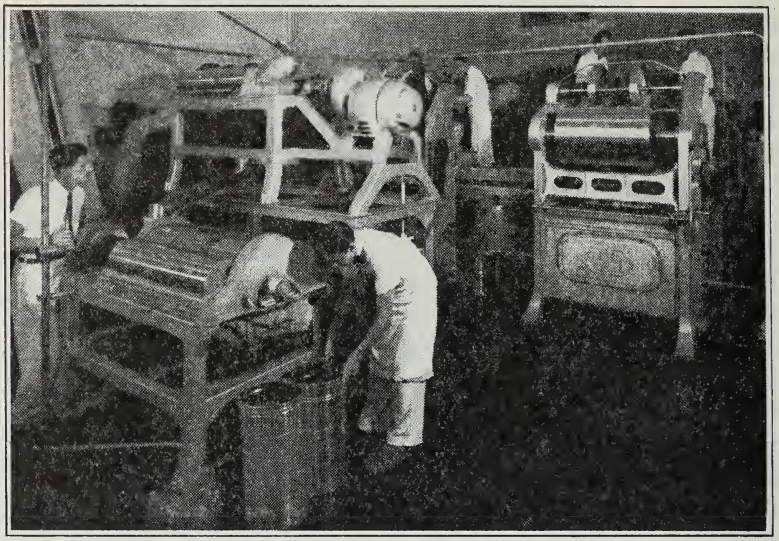

Fig. 2.—Citrus-juice extraction and straining equipment. (Courtesy of F. W. Bireley Company.)

prunes—the same precautions stressed for the bottled juice should be observed; namely, only prunes of high quality and of the current or the last season's crop should be used and the extractions should be made at not above 190° F. Small prunes give a juice of very undesirable flavor and old prunes impart a tobaccolike odor and flavor to the juice. Such fruit should not be used for human food in any form. Prune beverage retains its flavor much longer and better in enamel-lined than in plain tin cans.

While California canned grapefruit juice has been unable to compete with that of Florida and Texas, it is possible that a blend of California grapefruit and orange juices would be able to meet that competition successfully. It is a very pleasing drink.

Other promising blends are orange juice and apricot purée, grapefruit juice and prune beverage, orange and carrot juice, grapefruit and celery juice, and Boysen or Young blackberry and orange juice.

For methods to be followed in the extraction and canning of these various juices, see Circular 344, cited in footnote 6 (p. 5).

Frozen-Pack Juices.—It was found by Cruess, Overholser, and Bjarnason[11] more than twenty years ago that various fresh juices frozen in airtight containers and stored at 0° F retained their fresh character-

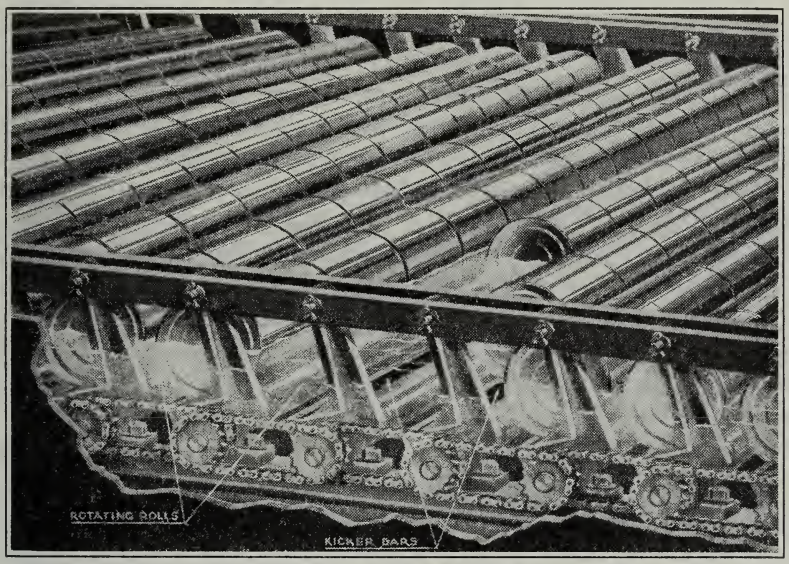

Fig. 3.—Continuous agitating heater for very rapid pasteurization of canned juices. (Courtesy of Thermal Research Corporation.)

istics for at least two years. Eckart and Cruess[12] reported that fresh pineapple juice retained its quality fairly well in the frozen condition in airtight containers. Tressler, Joslyn, and Marsh (see footnote 7, p. 5), as well as Joslyn and Marsh (see footnote 6, p. 5) and others recommend the preservation of fruit juices by freezing, when it is desired to retain the juice in a nearly fresh condition for a considerable period. Owing to the cost of freezing storage and the greater cost of transportation and distribution, the frozen-pack juices are somewhat more costly than those preserved by the usual bottling and canning procedures. Nevertheless, the method may attain importance for certain juices of

[11] Cruess, W. V., E. L. Overholser, and S. A. Bjarnason. Storage of perishable fruits at freezing temperature. California Agr. Exp. Sta. Bul. 324:1–20. 1920. (Out of print.)

[12] Eckart, T. G., and W. V. Cruess. Freezing storage of pineapple products. Fruit Products Journal 10:364–66. 1931.

delicate and unstable flavor. At present a moderate amount of orange juice is preserved in this manner for retail sale, and large quantities are so preserved in bulk for subsequent use in preparation of "dairy base" or other products. See Circular 344 for details of freezing juices.

For institutional use and for a short storage period of two or three weeks, paraffin-lined cardboard cups or tubs or friction-top cans may be used. For prolonged storage, airtight containers are advised.

In sales trials made by this Division during the period 1920 to 1924, a frozen-pack punch sirup proved very popular. It was prepared by mixing aproximately 1 part of concentrated lemon juice, 1 part of concentrated orange juice, and 3 parts of a deeply colored, concentrated juice or sirup, such as red-grape concentrate, pomegranate sirup, or Logan or other blackberry sirup. The thoroughly mixed blend was packed in paraffined cardboard, slip-cover, cylindrical cartons and stored at 0°–10° F. The consumer merely added water to the frozen sirup which on melting chilled the drink. With the better quality of fruit concentrates now available, a product of this type should be well received. It could be marketed through the regular frozen-pack food channels and ice cream stores.

The punch sirup was also pasteurized in bottles in our tests and distributed in grocery stores without refrigeration. But its shelf life is then rather short—probably not more than two months.

Beverage Sirups for Home Use (Squash Sirups).—In England and in many of its possessions and dependencies, bottled fruit sirups are very generally used in the home for preparing squashes by diluting the sirups with plain or carbonated water. They are also used in mixed alcoholic drinks.

The procedure for preparing and preserving the sirups is simple. Sugar is added to the fresh juice to give a sirup of medium density, 60°–70° Brix, and it is preserved with sodium benzoate or sulfur dioxide or by pasteurization at 175° F. Juices from fruits rich in pectin should be treated with a pectic enzyme to prevent jelly formation.

In a recent visit to Egypt, it was observed that orange, lemon, lime, pomegranate, grapefruit, strawberry, and mango squash sirups were popular. The principal objection to such sirups is that the dilution of 5 or 6 to 1 with water before serving is so great that they use relatively little fruit.

In experimental production and trial sales of fruit-beverage sirups for home use by this station (Bulletin 359; see footnote 9, p. 6), the beverages were found to be much more satisfactory if the juices were sweetened only enough to permit dilution with about 2 parts of water to 1 of sweetened

juice. Berry juices, sweetened apricot purée, and a sweetened mixture of orange and lemon juices were satisfactory. See Shallah and Cruess.[13]

For further details of preparing and preserving squash sirups see Charley and Harrison.[14]

"Dairy-Base" Beverages.—Noncarbonated, sweetened, and diluted unfermented orange drinks are now rather widely distributed in milk bottles by milk dealers and others who prepare them from "dairy-base" sirups. There should be a potential demand for other fruit beverages of similar nature. The procedure for orange "dairy-base" sirups is described in Circular 344 (cited in footnote 6, p. 5).

Possibly, among California juices, undiluted prune beverage, and the diluted beverages made from sweetened Boysen blackberry, apricot, peach, and pomegranate juices might find favor as "dairy-base" drinks. It would seem that apple and grape juices should be sold undiluted if distributed as "dairy" beverages, for they are very low in cost and retain their flavor well. They could be distributed by dairy delivery companies.

Concentrates.—Since concentrated fruit juices are used primarily for the preparation of unfermented drinks rather than for other purposes, they are included in this chapter.

The most common method of concentrating consists in boiling the juice under a high vacuum in a vacuum pan; preferably at a temperature not above 120° F. For details see Tressler, Joslyn, and Marsh (footnote 7, p. 5), Charley and Harrison, Cruess,[15] Irish,[16] or other reference. The vacuum pan should be constructed of stainless steel, Monel metal, Inconel alloy, or other alloy not attacked by the juice. Citrus and apple juices should be deaerated and flash-pasteurized; grape and berry juices should be flash-pasteurized before concentration. Orange concentrate retains its flavor better if some sugar is added to the juice before concentration. Vegetable juice concentrates can be made as described for fruit concentrates.

Much of the volatile flavoring and aroma is lost in ordinary vacuum-concentrating. In the Serailian process, the Pfaudler ester impregnation process, and in an improvement on these by Mottern,[17] a portion of the distillate containing the volatile constituents is collected and returned to the concentrate.

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[13] Shallah A., and W. V. Cruess. Canning of apricot juice. Fruit Products Journal 13:205. 1934.

[14] Charley, V. L. S., and T. H. J. Harrison. Fruit juices and related products. Imperial Bureau of Horticulture and Plantation Crops, Technical Communication 11:1–103. 1939. (Price 5 shillings.)

[15] Cruess, W. V. Commercial fruit and vegetable products. 2d ed. x + 798 p. McGraw-Hill Book Company, Inc., New York, N. Y. 1938.

[16] Irish, J. H. Fruit juice concentrates. California Agr. Exp. Sta. Bul. 392:1–20. 1925. Revised 1931. (Out of print.)

[17] Mottern, H. H. Concentrated apple juice. Fruit Products Journal 17:68–70. 1937.

Juices may be concentrated by freezing out some of the water as ice crystals and removing these in various ways; as by centrifuging, by metal draper, or by screening. See Tressler, Joslyn, and Marsh (footnote 7, p. 5); Charley and Harrison (footnote 14, p. 11); or Cruess (footnote 15, p. 11), for further details. The ultimate practical concentration is about 50° Brix; whereas in a vacuum pan about 72° Brix is readily attainable. In the freezing process, oxidation is severe; therefore, the juices should be flash-pasteurized to destroy enzymes before concentration. Cruess[18] found that a very satisfactory concentrate was obtained by blending concentrates made by freezing with those made by vacuum concentration to give a product of 60°–65° Brix.

Concentrates are preserved with sodium benzoate, cold storage, or by pasteurization. The second is the best of these.

They are used after diluting to beverage strength with water or after diluting and sweetening. They are also useful in preparing sirups for making carbonated beverages. See the next section.

They are, however, not so stable as squash sirups and are inclined to darken rather rapidly and to change in flavor when stored at room temperature.

Carbonated Beverages.—Several billion bottles of carbonated, non-alcoholic beverages are consumed in the United States annually (Bulletin 359, cited in footnote 9, p. 6). Extremely little of this total contains any fruit juice. Some in the past has been flavored with so-called "true fruit flavors," which are usually principally imitation fruit flavor. Fruit beverages contain valuable dietary substances not found in the usual carbonated beverage; for example, vitamins and certain mineral elements.

Since fruits are now abundant and low in cost and since the technology of preparing carbonated beverages from them has been well developed, there would appear to be no unsurmountable technical or economic difficulty in increasing the use of fruits in these products.

During 1923 and 1924 the Fruit Products Laboratory of this station produced carbonated fruit beverages on a small commercial scale and sold them through grocery stores in the Oakland and Berkeley area in order to test consumer opinion. The demand grew rapidly beyond the capacity of the facilities. The retail prices were 10 cents for a single 7-ounce bottle, 15 cents for two bottles, and 75 cents for a dozen bottles, plus the usual deposit for the empty bottles. The most popular beverages were orange, red-grape blend, fruit punch (a blend of several juices), lemon, Logan blackberry, and strawberry. The cost of producing the bev-

[18] Cruess, W. V. Commercial production of grape syrup. California Agr. Exp. Sta. Bul. 321:410–16. 1920. (Out of print.)

erages ranged from 2.07 cents a bottle for lemon to 3.50 cents for raspberry beverage, exclusive of the cost of the bottle. The procedures used in preparing and bottling the beverages were those developed in this laboratory and described in Bulletin 359 (cited in footnote 9, p. 6). This bulletin is now out of print but the information is presented fully by Tressler, Joslyn, and Marsh (cited in footnote 7, p. 5).

Since completion of these sales trials, the commercial production of carbonated beverages containing orange juice has increased; and there is increasing interest in other fruit beverages among bottlers.

In Holland and in Egypt, carbonated beverages of 25 to 50 per cent fruit-juice content are produced. The juices were lightly sweetened, diluted with water, carbonated at low temperature in bulk; filled into bottles of approximately 12-ounce size, sealed, and pasteurized at 140° F. Pineapple, grapefruit, orange, and apple were most popular. It is our belief that fruit beverages of this type have greater possibilities than those that are highly diluted. It would be desirable for federal and state food authorities to establish minimum fruit content for carbonated fruit beverages.

Preservation of Juices by Chemical Preservatives.—Sodium benzoate, benzoic acid, and sulfurous acid (sulfur dioxide, fumes of burning sulfur) are the only chemical preservatives permitted by law. Two new preservatives are under consideration by the federal Food and Drug Administration.

Much barreled and bottled apple juice is preserved in America with sodium benzoate, and various juices and sirups are preserved in Great Britain with sulfurous acid. Some orange "dairy base" and most soda fountain sirups are preserved with benzoate.

There is a strong consumer prejudice against food products preserved with benzoate because of the former practice of concealing spoilage and inferiority by its use. At present, however, all juices and other products so preserved are subject to strict governmental inspection and, hence, are usually of good quality.

The usual concentration of sodium benzoate required for preservation of juices is about 0.1 per cent by weight; but Cruess, Richert, and Irish[19] found that juices from thoroughly ripe fruits and therefore of subnormal acidity may require as much as 0.30 per cent. At 0.1 per cent benzoate or higher, the juice possesses, to most consumers, a decided "scratchy" or "burning" taste.

With sulfurous acid, such high concentration (0.1 per cent or more

[19] Cruess, W. V., P. H. Richert, and J. H. Irish. The effect of hydrogen ion concentration on the toxicity of several preservatives to microörganisms. Hilgardia 6(10): 295–314. 1931.

as sulfur dioxide) must be used in order to preserve juices permanently that the flavor and odor are objectionable. It is valuable, however, in lower concentrations for checking undesirable changes caused by oxidation. For this purpose 0.02 per cent as sulfur dioxide is adequate. It is not objectionable at this concentration. A combination of about 0.05 per cent benzoate and about 0.02 per cent sulfur dioxide maintains orange and apple juices in a nearly natural condition for a considerable period.

Preservation by Sterilizing Filtration.—In Switzerland and Germany, much apple juice is preserved in sterile bottles by close filtration. The process is in use also in Holland and England. It was devised by Professor Boehi in Switzerland in 1912. For details of the procedure see Charley and Harrison (cited in footnote 14, p. 11).

In brief the procedure is about as follows: apples of suitable flavor and maturity for juice are crushed and pressed. The juice is roughly filtered and then filtered through a Seitz "germ-proofing" sterile pad (or similar filter) and is conveyed by sterile equipment to an impregnating pump, where it is impregnated to about 120 pounds pressure with carbon dioxide. It is pumped into sterile 5,000–10,000-gallon wax-lined or glass-lined steel tanks previously freed of air. It is stored at 50°–54° F under about 120 pounds carbon dioxide pressure. The few yeast cells and mold spores that may be present are held in check by the carbon dioxide.

At the time of bottling the juice is drawn off. A small amount of the carbon dioxide is left in the juice to render it faintly sparkling; but most of the gas is allowed to evolve from the juice and is recovered and compressed for future use. The juice is again close-filtered to remove all yeasts and molds, bottled in bottles sterilized by heat and sulfur dioxide, and sealed with sterile caps. It is not heated.

The juice is brilliantly clear and free of cooked taste, although the flavor is altered perceptibly from that of the fresh.

In America the process and equipment would be much more costly than are our usual methods of preservation, and the product would have to command a higher price. Nevertheless, it might fill a possible limited market to consumers who demand a brilliantly clear juice. As previously stated, the present trend in the United States is toward the "natural" juices; that is, cloudy or pulpy juices canned, or bottled and preserved by pasteurization. The "Seitz-Boehi cold process" has been commercially used for apple juice in Washington state and to some extent in California.

Other Methods of Preservation.—In the Katadyn process (see Charley and Harrison cited in footnote 14, p. 11), a weak direct electric current

is passed through the juice between silver electrodes. Minute quantities of silver are reported to be taken up by the liquid and are said to exert a sterilizing and preservative effect. There appears to be much uncertainty as to whether this procedure is permissible under American food and drug regulations owing to the alleged presence of silver in the juice.

In the Matzka process, heat is applied in addition to an electrolysis treatment between silver electrodes. According to Arengo-Jones of Canada, who has investigated the process (see Charley and Harrison cited in footnote 14, p. 11), the Matzka process is essentially one of simple pasteurization.

Ultraviolet light has been tested as a sterilizing agent for juices. It is successful with white juice in thin layers, but causes undesirable changes in flavor.

We have found that ultrasonic waves of high frequency can be used to sterilize small quantities of juice but on a large scale have not proved very effective; that is, complete sterilization is almost impossible of attainment. In tests in this laboratory high-frequency electric current and short radio waves failed to sterilize juices except by their heating effect.

Powdered Juices.—Lemon and orange juices have been dried commercially by the Merrill-Soule spray drying process and equipment. To these and other fruit juices must be added corn sugar, milk sugar, milk, or other agent that will prevent formation of a gummy mass or sirup. The juices are rich in levulose, which is a very hygroscopic sugar and difficult to dry to a powder. In the drying process a great deal of the fresh fruit aroma and flavor is lost by volatilization, and the added sugar necessary in maintaining a powder considerably increases the sweetness; hence some juices should be acidified with fruit acid, such as citric, or with lemon juice before drying. Tressler, Josyln, and Marsh (cited in footnote 7, p. 5) give details of equipment and procedure. Spray driers other than the Merrill-Soule may be used; for example, the well-known Jensen-Gray spray drier.

Several years ago a simple procedure[20] was devised in this laboratory for converting juices into a granular or powdered form. The juices were first concentrated to about 70° Brix. Anhydrous dextrose was then added until a solid mass resulted from the absorption of water by dextrose to form hydrated dextrose crystals. From 1 to 2 parts of dextrose to 1 part by weight of concentrate was usually required, the proportion depending

[20] Cruess, W. V., J. H. Irish, and P. H. Richert. Powdered fruit juices. Pacific Rural Press 67:741. 1929.
Richert, P. H. Solid grape products. The aim of California investigators. Fruit Products Journal 9:39–40. 1929.

upon the amount of water absorbed by the dextrose. It has also been found possible to add the required amount of dextrose before concentration. The solidified mass was ground to the desired degree of fineness. It dissolved readily in water and was a satisfactory base for unfermented drinks. On prolonged standing, however, the granular or powdered product tended to "cake" unless stored in airtight containers. It is believed that such a product would be useful in soda fountains, in the manufacture of prepared gelatin desserts, and in the home for preparing refreshing beverages and frozen desserts. It would be convenient for use by campers, "hikers," and others who require highly concentrated foods.

FRUIT SIRUPS FOR TABLE USE

Acording to statistics of the United States Department of Agriculture, about 4,000,000 gallons of maple sirup, about 35,000,000 gallons of sorghum sirup, about 20,000,000 gallons of sugar-cane sirup, and about 125,000,000 gallons of blended sirups (imitation maple and others) are produced annually in the United States. Cruess (cited in footnote 15, p. 11) estimates cane molasses for cooking purposes at 25–30 million gallons and corn sirup for table use at 30–35 million gallons a year. The grand total is about 240,000,000 gallons of sirups for household use annually.

If all of this were made from fruit of an average of about 15 per cent sugar content, over 6,000,000 tons of fresh fruit would be required; if made from dried fruit of 60 per cent sugar content, about 1,600,000 tons. If only 10 per cent of it were made from fruit, about 600,000 tons of fresh fruit or about 160,000 tons of dried fruit would be needed. These estimates are offered to indicate that production of table sirup is an important industry.

The usual wholesale price of blended sirups is about $1.00 a gallon. A ton of grapes will yield about 40 to 45 gallons of sirup, and a ton of raisins about 150 gallons. Yoder[21] gives the cost of manufacture of sugar-cane sirup at 11 cents a gallon. Canning, boxing, transportation, and selling costs must be added. Consequently, it can be seen that the return per ton of grapes, raisins, or other fruit would not be very great, and probably only surplus and cull fruit could be used. Nevertheless, under present conditions of surplus production of grapes, raisins, apples, and prunes, table-sirup manufacture might be considered, remembering that as with all new food products, much time, money, and effort would be needed to introduce fruit table sirups on the market.

Sirup suitable for table use was prepared from red wine grapes on a

[21] Yoder, P. A. Growing sugar cane for syrup. U. S. Dept. Agr. Farmers' Bul. 1034:1–35. 1919.

small commercial scale by this station[22] from 1919–1925, and was favorably received in sales trials. The bulletin on the subject (Bulletin 321, cited in footnote 18, p. 12) is out of print; therefore, the method of manufacture will be briefly outlined. It was as follows: Thoroughly ripe red wine grapes of the common varieties such as Zinfandel, Carignane, and Alicante Bouschet were crushed, stemmed, heated to 160° F, and pressed. The juice was filtered and then concentrated *in vacuo* to 67°–68° Brix. The sirup was allowed to stand several weeks to deposit excess cream of tartar. It was then bottled and pasteurized at 150° F. Reenameled type-L tin plate could be made into the usual sirup-can form and used for the sirup. The color bleaches and corrosion is severe in plain tin. At concentrations much above 68° Brix, crystallization of dextrose to give a solid or pasty mass will occur; but at or below 68° Brix, yeast will usually develop and cause spoilage in time; hence the need for pasteurization.

The flavor is much improved if equal amounts of muscat and red wine grapes are used in preparing the sirup. The sirups are useful not only on hot cakes and waffles, in such products as jelly rolls and gelatin desserts, but also in fruit punches and other drinks.

White-grape sirup may be made in similar manner except the grapes are pressed without heating and the juice is heated to about 175° F and cooled before filtration. Use of equal amounts of muscat for flavor and of other white grapes of neutral flavor, such as Thompson Seedless, is recommended.

White-grape sirup darkens slowly in storage, but the flavor remains pleasing. In plain tin it retained its light color for a much longer period than in glass, in our tests, owing, probably, to the reducing action of nascent hydrogen evolved from the metal. If desired, part of the acidity may be neutralized in the juice by heating with a calculated amount of calcium carbonate, cooling, and filtering. Calcium tartrate is precipitated and may be recovered for use in tartaric acid manufacture.

Fresh grape juice may be preserved with sulfur dioxide for future use in sirup making[23] and the sulfur dioxide removed during sirup manufacture.

Apple juice and Bartlett pear juice may be converted into cooking and table sirups by treating with pectinol or other pectic enzyme as directed by Marshall,[24] filtering, and concentrating in a vacuum pan or in a "boiled cider" concentrator[25] in the open to about 70° Brix. Unless

[22] Cruess, W. V., and D. S. Glenn. Table syrup from grapes. Fruit Products Journal 9:366–68, 383. 1930.

[23] Cruess, W. V., and E. W. Berg. Removal of sulfurous acid from grape syrup. Industrial and Engineering Chemistry 17:849. 1925.

[24] Marshall, R. E. The relation of clarifying and sterilizing treatment to sedimentation of apple juice. Fruit Products Journal 16:328–29, 331. 1937.

the juice is treated with a pectic enzyme, the sirup is apt to become a jelly. The apple sirup is useful in making mincemeat and apple butter as well as on the table. The pear sirup is satisfactory for table use.

Raisins yield a pleasing table sirup. The procedure used in our experiments consisted in stemming, passing the raisins through the saws but not the seeder section of a raisin seeder in order to puncture the skins, extracting several times in a diffusion battery with hot water, and then proceeding as described for white-grape sirup. Muscat raisins should be used because of their rich flavor.

Dried figs give a sirup of rich flavor when handled as described for raisins. The figs are coarsely ground or sliced before extraction. Dates may be crushed and then extracted, although it is very difficult to filter the date infusion brilliantly clear. In neither case should the final concentration exceed 70° Brix, and both sirups should be pasteurized. Fig sirup is not laxative; the so-called "fig sirups" used as laxatives contain an added laxative such as senna or cascara sagrada.

From prunes a fairly satisfactory table sirup can be secured if prunes of good quality are extracted with water at 175°–180° F and the infusion concentrated in a vacuum pan to 68°–70° Brix. The sirup is much less viscous if the infusion is treated with a pectic enzyme.

Table sirups may be made also by sweetening with cane sugar, berry juices previously treated with a pectic enzyme.

Orange juice should be partially neutralized with calcium carbonate, filtered, decolorized with carbon, and again filtered before concentration. The sirup tends to darken and develop a "stale orange" flavor.

FRUIT CANDIES

The per-capita consumption of commercially made candy in the United States was 15.9 pounds in 1939, according to the United States Department of Commerce. Much candy is also made in the home. If a total per-capita annual consumption of 20 pounds is assumed, the total would be about 2,600,000,000 pounds, or about 1,300,000 tons. In other words, the use of fruits in candy offers an attractive field of development. Most of these candies contain no fruit. Our investigations, begun in 1918, show that fruits can be utilized readily in many kinds of candy. Fruit candies are of greater dietary value than other candies because of the vitamins, minerals, and other special food values of the fruits. Also, they are less "filling," that is, not so rich; therefore more may be eaten without discomfort. Figure 4 shows a type made with dried fruit.

The high cost of candied fruits prevents their general use.

[25] Anonymous. Reducing cider to boiled cider. Hydraulic Press Mfg. Co. Bul 82: 1–16. 1930.

Our experiments have developed inexpensive formulas for the use of fruits in candies, many of which can be prepared at a cost not above that of popular candies of the 5-cent bar type. Space will not permit a full presentation of our results. For formulas and further details see Extension Circular 10 and journal articles.[26]

In Latin American countries and in Spain, fruit-jelly candies are very popular. They are usually packed in rectangular tin boxes with hinged

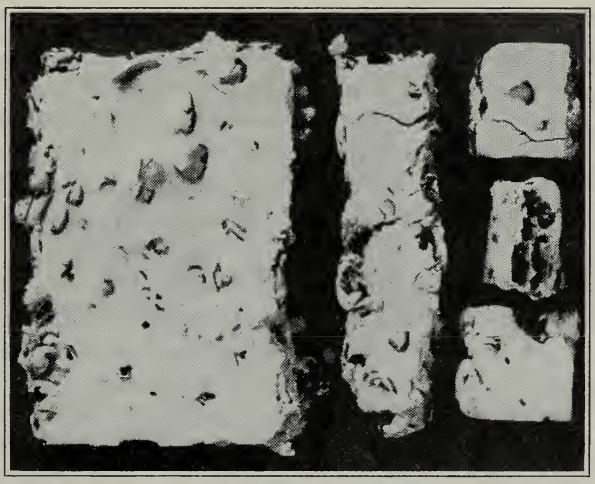

Fig. 4.—Dried-fruit candies.

tops; often in the form of a loaf about $4 \times 6 \times 10$ inches which is sliced at the table for serving as a dessert. In Aix en Provence, France, the manufacture of fruit-jelly candies is an important industry. These candies are popular throughout France. The procedure is similar to that in the formula given in Extension Circular 10.

In Bari, Italy, a large factory, that of Lorenzo La Rocca, was visited recently, in which are prepared pure-fruit-jelly bars of two sizes, selling for the equivalent of about 1 to 3 cents each. Demand was reported to be excellent. Sales trial in Berkeley in 1920 proved that American consumers also are fond of such candies.

Dried fruits may be used in chocolate fudges, divinity fudges, caramels, marshmallows, nougats, and various other standard candies as well as in uncooked candies. For formulas see Extension Circular 10.

[26] O'Neill, Agnes, and W. V. Cruess. The home preparation of fruit candies. California Agr. Ext. Cir. 10:1–31. Revised. 1938.

Cruess, W. V. Fruit candies. Manufacturing Confectioner 11(3):33–36; (4):30–34; (8):25–29. August, 1931.

Cruess, W. V. Utilization of fruits in the candy industry. Fruit Products Journal 19:164–66, 174. 1939.

PECTIN

At present considerable quantities of dried apple chops, peels, and cores are used in preparing powdered pectin and pectin sirups; and waste lemon peels are used in preparing powdered pectin. The powdered pectins find extensive use in jelly and preserve factories; and the pectin sirups in making jellies and preserves in the home. Some pectin is used as a medicine in the treatment of diarrhea. For an outline of the procedures used in preparing pectins commercially see *Commercial Fruit and Vegetable Products* (cited in footnote 15, p. 11) as well as the references listed therein, and other references given below.[27]

Expansion of the market for pectin appears to depend upon the discovery and development of new uses for it, both in foods and for industrial purposes. The California Fruit Growers' Exchange research staff and others are making progress in that direction.

BASES FOR JELLIES AND JAMS

Jelly Juices.—In 1921–1923 and subsequently, considerable experimental work was done in this station on the preparation, preservation, and utilization of fruit juices to be used in jelly making.[28]

In brief, the recommended procedure consists in cooking crushed or sliced fresh fruits of suitable variety with water to cover, until soft; pressing; filtering the juice and concentrating it, preferably in a vacuum, until it will give a good jelly if it is boiled to the jellying point with an equal volume of cane sugar. The unsweetened juices are preserved by pasteurization; namely, by heating to 180°–212° F, canning or bottling scalding hot, placing containers on sides to sterilize caps or lids, and cooling. Re-enameled type-L or similar cans or glass containers must be used for red juices.

To use the juice the housewife or manufacturer adds sugar in equal amount and cooks to the jellying point, normally about 8° F above the

[27] Wilson, C. P. Relation of chemistry to the citrus products industry. Industrial and Engineering Chemistry **20**:1302–7. 1928.

Wilson, C. P. The manufacture of pectin. Industrial and Engineering Chemistry **17**:1065–68. 1925.

Wilson, C. P., *et al.* U. S. Patent No. 1,497,884. U. S. Patent Office, Washington, D. C. June, 1924. (In using patented processes, permission must be obtained from the holders of the patents.)

Rooker, W. A. Fruit pectin: its commercial preparation and uses. vi + 170 p. Avi Publishing Co., Inc., New York, N. Y. 1928.

[28] Cruess, W. V., and L. Singh. Marmalade juice and jelly juice from citrus fruits. California Agr. Exp. Sta. Cir. **243**:1–8. 1922. (Out of print.)

Cruess, W. V., and G. L. Marsh. Fruit jelly juices. Fruit Products Journal **11**: 325–27. 1932. (Out of print.)

Cruess, W. V. Utilization of surplus plums. California Agr. Exp. Sta. Bul. **400**: 1–21. 1926. (Out of print.)

boiling point of water—220° at sea level. The jelly maker is saved the trouble and labor of preparing the raw fruit and may make jelly at any time of the year. Many jelly manufacturers preserve such jelly juices for their own use; but so far as we know, such juices are not on the retail market for household use. Our sales trials indicate a latent demand for these products for home use. Any one who may wish to undertake their manufacture should make certain that no patents are infringed.

In Spain, the Seville (sour) orange is converted into a canned marmalade base and exported to England and elsewhere for use in the commercial preparation of marmalade. Cruess and Singh (cited in footnote 28) developed a satisfactory procedure for preparing and canning a marmalade juice from California oranges and lemons.

Jam Bases.—We have packed and sterilized in cans undiluted purées of peaches, apricots, plums, and pears. These were found suitable for preparing fruit jams and butters in the home or factory by adding an equal weight or volume of sugar and cooking to the desired consistency.

Also the sliced, crushed, or coarsely ground fruits previously prepared as for canning in sirup, were steamed, packed hot in cans, sealed, processed in boiling water, and cooled. For household use in jam making, such a pack is probably preferable to the purée.

Plum and apricot jam bases were kept in plain tin cans for over three years without loss from corrosion.

FROZEN PACK

This station[29] was among the first to undertake an investigation on the freezing storage of fruits in small containers for retail distribution, although the barreling of berries and some other fruits for use in preserve factories had been done commercially previous to our studies. In recent years interest and research in frozen pack have greatly increased, and the litertaure now is extensive. Only a few of the leading references will be cited; for additional lists see Tressler and Evers[30] or Cruess (footnote 15, p. 11). Several other references[31] may also be consulted.

Owing to the fact that the principles and details of preparing, packag-

[29] Cruess, W. V., and E. L. Overholser. Freezing fresh fruits in cans. Canning Age. 6:97–99. 1925.

[30] Tressler, D. K., and C. F. Evers. The freezing preservation of fruits, fruit juices and vegetables. x + 369 p. Avi Publishing Co., Inc., New York, N. Y. 1936.

[31] Diehl, H. C., W. T. Pentzer, J. A. Berry, and C. E. Asbury. Suggestions for freezing foods are outlined. Western Canner and Packer 26(5):31–33; (6):39–41; (7):33–35; (8):43–44. 1934.

Joslyn, M. A. Preservation of fruits and vegetables by freezing storage. California Agr. Exp. Sta. Cir. 320:1–35. 1930. (Out of print.)

Joslyn, M. A., and G. L. Marsh. Changes occurring during freezing storage and thawing of fruits and vegetables. California Agr. Exp. Sta. Bul. 551:1–40. 1933. (Out of print.)

ing, freezing, storing, and distributing frozen-pack fruits are well covered in the publications cited, these processes will not be presented here except in outline.

Well-ripened fruits of suitable varieties are prepared as for canning. They are then packed with a suitable amount of dry sugar or suitable sirup in cartons or cans and frozen quickly by some system that will promote rapid exchange of heat between the fruit and the freezing medium. They are stored at a low temperature, preferably about 0° F, and distributed under freezing refrigeration to consumers.

The consumer usually thaws the fruit before serving, although it may also be served in the frozen state.

Sweetened purées may be frozen in cans or cartons for use as frozen desserts.

Apricots, peaches, pears, and apples tend to become brown and off-flavored if not parboiled, or frozen in sirup. Sirup, however, adds greatly to the weight of the packed product. Marsh and Joslyn, and also Woodruff,[32] find that dipping of the cut fruits in dilute sulfur dioxide, salt, phosphoric acid, or citric acid solutions before freezing prevents darkening and minimizes undesirable oxidative changes in flavor.

Citrus juices and other juices retain their fresh flavor very well in the frozen state when packed under exclusion of air.

Frozen fruits have been well received, and the principal obstacles to a more rapid increase in their use is the scarcity of retailers' freezing-storage facilities, and the rather high retail cost of the products.

FRUITS IN ICE CREAMS AND ICES

While considerable fruit is used at present in ice creams and ices, often so little is added that reinforcing with artificial color and flavor is necessary. Investigations conducted by the divisions of Fruit Products and Dairy Industry of this station[33] have demonstrated that the addition of artificial color and flavor is unnecessary if sufficient fruit is used; and that the frozen products are greatly improved by use of a larger proportion of fruits than is customary.

Since the subject is well covered in Circular 331, the presentation here will deal only with subjects not found in the circular.

Special Packs of Canned Fruits.—We have packed, experimentally,

[32] Marsh, George, and M. A. Joslyn. Unpublished data.
Woodruff, J. G. Preserving fruits by freezing. I. Peaches. Georgia Agr. Exp. Sta. Bul. 163:1–46. 1931.

[33] Turnbow, G. D., and W. V. Cruess. Investigations on the use of fruits in ice cream and ices. California Agr. Exp. Sta. Bul. 434:1–38. 1927. (Out of print.)
Cruess, W. V., W. C. Cole, and M. A. Joslyn. Fruits in ice cream and ices. California Agr. Exp. Sta. Cir. 331:1–28. 1933.

apricots prepared for use in ice cream as follows: Thoroughly ripe apricots were pitted, ground, sweetened with 20 per cent of sugar (2 pounds to 8), heated to boiling, canned boiling hot, sealed, and processed a short time in boiling water. One no. 10 can of this fruit would be used with enough basic ice-cream mix to give 5 gallons of fruit-ice-cream mix, or about 10 gallons of finished ice cream. In using such generous amounts of fruit, care must be taken that the finished product is above the food-law minimum in fat content.

Similar products were made with peaches and pears. The pear flavor carries very well in both water ice and ice cream—is, in fact, superior to the peach in that respect.

In some cases the diced fruits are desirable. In figure 5 is illustrated equipment for dicing fruits to be canned as fruit cocktail, a product useful in "tutti frutti" ice cream.

Use of Avocados.—Use of avocados in ice cream and experiments on other avocado products have been reported by Cruess and Harold.[34] We have found that the ground, lightly sweetened pulp may be preserved indefinitely in the frozen state and is equal to the fresh for use in ice cream. Preservation by heat destroys the fresh flavor and renders the fruit unfit for use in ice cream. The frozen-pack fruit could be prepared by shippers or others in southern California from sound, off-grade fruit and distributed to the ice-cream industry.

Prunes in Ice Cream.—Dried prunes of the French variety gave, in our experiments, ice creams and ices not only of very pleasing flavor, but also with the mildly laxative properties of that fruit. The fruit is cooked and sieved and the resulting purée added to the basic mix. For the convenience of ice-cream makers, the purée of "sieved prunes" may be canned very easily. See Bulletin 483 of this station.[35] See Circular 331 (footnote 33, p. 22) for further details. Fresh prunes may be pitted by the machine shown in figure 6 and ground for use in ice cream.

Other Fruits and Products in Ice Creams and Ices.—Purées, pulps, and sauces made of nectarines, plums, fresh prunes, cherries, and apples have proved to be satisfactory flavor bases for ice creams and ices. Mixed fruits such as commercially canned fruit cocktail, fruits for salad, mixed frozen pack, or mixed fresh fruits give very pleasing ice creams and ices. The mixed fruits should be chopped, diced, or coarsely ground. Certain blends of fruit juices such as red grape, orange, and berry are particularly well suited for the preparation of ices.

[34] Cruess, W. V., and E. Harold. Investigations on utilization of cull avocadoes. Fruit Products Journal 7(6):12–14, 20. 1927.

[35] Mrak, E. M., and W. V. Cruess. Utilization of surplus prunes. California Agr. Exp. Sta. Bul. 483:1–34. 1929.

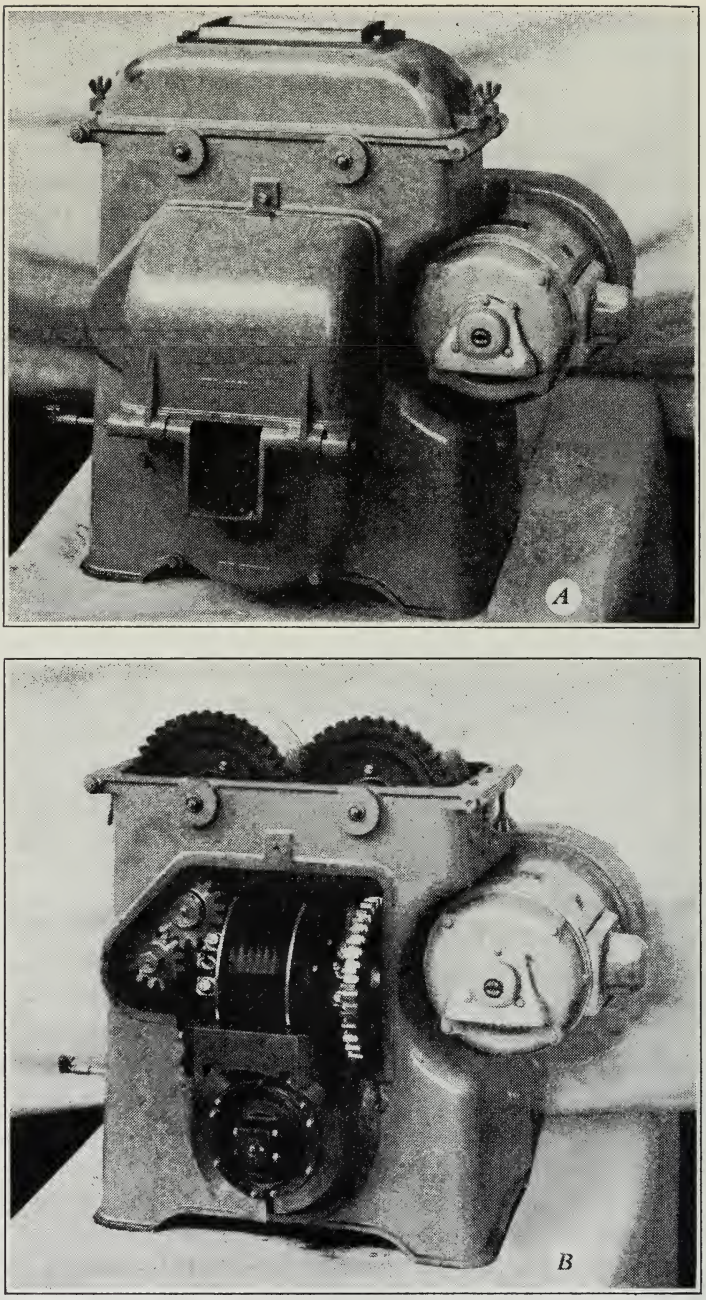

Fig. 5—Improved fruit dicer: *A*, closed; *B*, open. (Courtesy of Food Machinery Corporation.)

Joslyn and Cole[36] report as follows on the results of experiments on the use of wines in ice creams and ices: Claret and Riesling dry wines gave ices of pleasing flavor and good texture, and the ices have possibilities for desserts or as side dishes for meats. The following formula was satisfactory: wine, 25 per cent; cane sugar, 17 per cent; corn sugar, 5 per cent; acidity, 0.5 per cent total acid expressed as citric; pectin, 0.5 per cent; the remainder consists of regular basic ice mix. Muscatel,

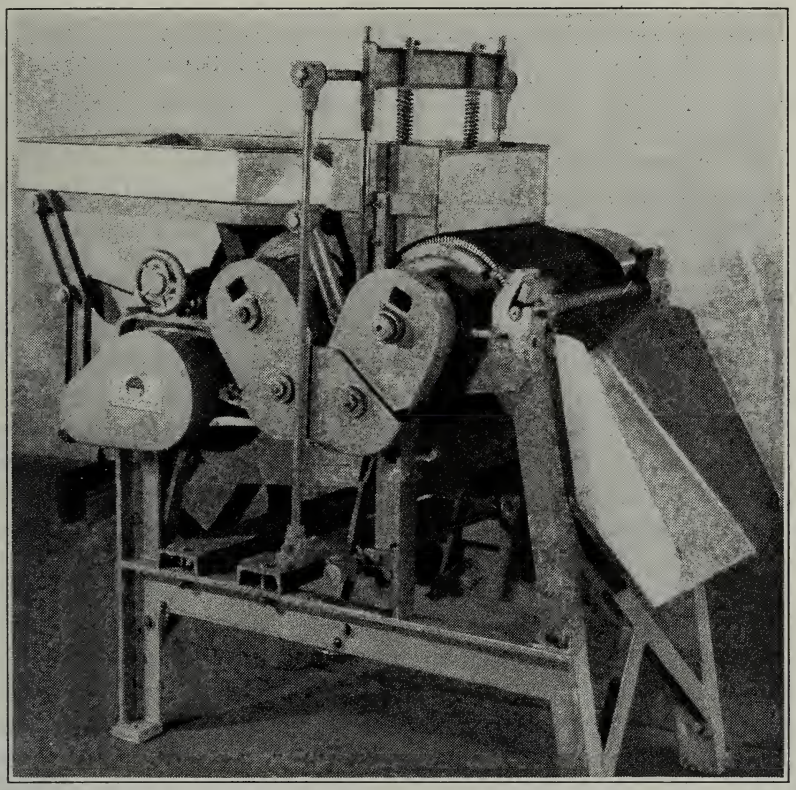

Fig. 6.—Fresh-fruit pitting machine. (Courtesy of Elliott Machinery Company.)

sherry, and port did not give ices of satisfactory flavor. None of the wines were satisfactory in ice cream. Prospective users of wine in ices or ice creams are warned that they must secure approval of state and federal liquor-control authorities. Penalties for violating regulations are very severe.

Fruits Canned for Use in Homemade Ice Creams.—In experiments conducted in this station, various fruits have been canned for making

[36] Joslyn, M. A., and W. C. Cole. The use of wines in ices. Wines and Vines 18(8):8. 1937.

ice creams and ices in the home. Figs, apricots, freestone peaches, and pears are particularly satisfactory. The ripe fruit is prepared as for canning in sirup as halves. It is then coarsely ground, mixed with 1 part of sugar to 4 of fruit, heated to boiling, canned hot, sealed, processed in boiling water until well cooked; and the cans are then thoroughly cooled. The product is somewhat better for use in home recipes if, before canning, a stabilizer is added, such as fruit pectin previously dissolved in sugar and water, or alginate, or gelatin.

If the fruit is whipped with an egg beater before placing in the freezing tray of the home refrigerator, and again as it begins to harden, the finished product is "fluffy" and not too dense. Or it may be added to an ice-cream mix or to a fruit-ice mix, recipes for which are available from dealers in home refrigerators.

Frozen Fruits.—The usual fruit ice or sherbet contains relatively little fruit. It is chiefly basic mix consisting of fruit acid, sugar, stabilizer, water, and added flavor or color, or both. Some fruit, usually 10 to 25 per cent, is added to this basic mix.

Frozen-pack fruits prepared and canned as outlined in the preceding section or prepared in similar manner from the fresh fruits give on freezing in a commercial freezer a healthful and pleasing all-fruit dessert. But, if the fresh fruit is used, it should be sieved to a fine consistency to avoid lumps; or should be cooked with the sugar until soft. Berries, apricots, freestone peaches, nectarines, and pears respond well to this procedure.

DRIED-FRUIT PRODUCTS

As a result of the investigations of Christie, Nichols, Mrak, and others of the Fruit Products Division, in part in coöperation with the divisions of Agricultural Engineering and Pomology of this station and other agencies, important improvements have been made in the drying of fruits and in the processing and packing of dried fruits. Examples are improvements in prune-dehydration practice and in prune-dehydrater design, walnut-dehydration practice and dehydrater design, dehydration of grapes, and the development of a satisfactory procedure for preparing and dehydrating a new product, dried cling peaches.

Dehydration affords a means of improving the quality of dried prunes and some other fruits, because it prevents fermentation and minimizes enzymic changes such as darkening of the flesh and deterioration of flavor during drying. See Bulletin 404[37] for further information.

Canned Prunes.—A satisfactory procedure is described in Bulletin 483 (cited in footnote 35, p. 23) for the canning of ready-to-serve prunes

[37] Christie, A. W. The dehydration of prunes. California Agr. Exp. Sta. Bul. **404**: 1–32. Revised 1929 by P. F. Nichols. (Out of Print.)

in light sirup. Thorough blanching before canning, acidification of the sirup, use of a deep head space, and of resistant type-L or similar tin plate are recommended. When so canned the fruit keeps well without serious corrosion of the plate.

We believe that canned or glass-packed, processed dried prunes of high moisture content, 30–33 per cent, packed without added liquid in a form similar to that of several products now on the market, would find considerably greater favor if extensively advertised. They are very suitable for eating out of hand and appeal to children particularly. The product keeps well, does not dry out in the sealed container and as long as the can is sealed, is immune to insect attack, molding, sugaring, and fermentation. Similarly, dried figs, peaches, dates, and pears may be packed in glass for eating out of hand.

Dry-Packed Canned Dried Figs and Raisins.—Dried figs and muscat raisins responded well to processing and packing in a manner similar to that used for dry-pack prunes. Sulfured dried fruits kept well in glass containers when packed in the above manner, but attacked the tin plate with formation of hydrogen sulfide gas when canned; also they darkened rather rapidly in the cans.

Such fruits cook quickly when taken from the container and heated in water or light sirup, so that preliminary soaking in water is unnecessary.

Improved Nonmetallic Packages.—Recently, transparent cellophane wrappings or bags of "Pliofilm" and other nearly moistureproof materials have been made available as moisture-retaining linings or wrapping for cartons. Also paper "cans" lined with a moisture-resistant material and sealed with tin ends have been perfected by one of the large can companies. Preliminary tests indicate that these packages are very resistant to diffusion of moisture. In other words, inexpensive packages of the "Pliofilm"-inner-liner and paper-"can" types greatly prolong the shelf life of dried fruits and deliver them in a moister, more attractive condition to the consumer.

Sugaring of Dried Fruits.—Investigations by Christie, Nichols, Mrak, and others of this laboratory, and by Hiltner of the California Dried Fruit Association demonstrated that sugaring of carton-packed prunes could be prevented by coating with a thin film of oil, as was done later commercially with raisins. An edible vegetable oil must be used because edible mineral oils are considered medicines by the food-and-drug authorities. Edible vegetable oils rancidify in time, although when accompanied by a natural anti-oxidant such as Avenex, rancidity is delayed. Also it was found by Cruess and Katzprowsky (unpublished

data) that coating of prunes and other dried fruits with a dilute solution of dextrin, pectin, gelatin, or other suitable food colloid delays sugaring and improves the appearance of the fruit.

Pitted Prunes.—Machines are now available for pitting fresh prunes. When dehydrated after pitting, the product is attractive in appearance and flavor, particularly if steamed or lightly treated with sulfur dioxide fumes to inactivate enzymes before drying. Dried prunes are pitted commercially for bakers' use; the improved, modern machines do very satisfactory work and leave practically no broken pits. The pitted dried prunes may be finely ground, as are figs, for paste; the paste is then brought to 35–40 per cent moisture, canned, and sealed scalding hot for bakers, candy makers, ice-cream makers, restaurant, and household use. If packed at the usual dried-prune moisture content of 20–25 per cent, the paste is too dense and tough to be easily used. See sections on fruit candies (p. 18) and fruit ice creams (p. 22) for methods of using prune paste or pulp in these products. The machine illustrated in figure 7 is useful for pitting dried prunes and dates.

Mrak found that prune pulp and paste can be used successfully in stuffed crackers, that is fruit "newtons," if cooked with a considerable proportion of invert sirup. If the customary corn sirup (glucose) is used, the filling rapidly dries out, and toughens after baking.

See section on cereal products (p. 31) for further suggestions.

Prunes have been shown by Morgan, Hunt, and Squier[38] to be very rich in vitamin G (riboflavin) and rich in A, both very important in human nutrition.

Apricots and Peaches.—In normal times the European markets take a large proportion of the dried-fruit output, including apricots and peaches. With the abundance and relatively low prices of fresh and canned fruits, as well as their convenience, it is difficult to increase American consumer interest in dried fruits.

Nevertheless, dried apricots and peaches are both excellent sources of vitamin A; are rich in basic mineral elements, that is, those that combat "dietary acidosis"; and have been shown by Whipple[39] to be very rich in the substances that promote hemoglobin formation. That is, they are valuable in combatting anemia, such as that following severe loss of blood, or after debilitating diseases such as influenza and pneumonia. If these facts were made known more generally, they should greatly stimulate the use of these fruits.

[38] Morgan, A. F., M. J. Hunt, and M. Squier. The vitamin B and G content of prunes. Journal of Nutrition 9:395–402. 1935.

[39] Whipple, G. H. Hemoglobin formation as affected by diet and other factors. American Medical Association Journal **104**:791–93. 1935.

Processing the dried fruits in dilute sirup improves their appearance and their edibility as a candy or between-meal "snack."

When ground to a paste, they are useful in bakery products, "newtons," and for rapid cooking into sauces and jams.

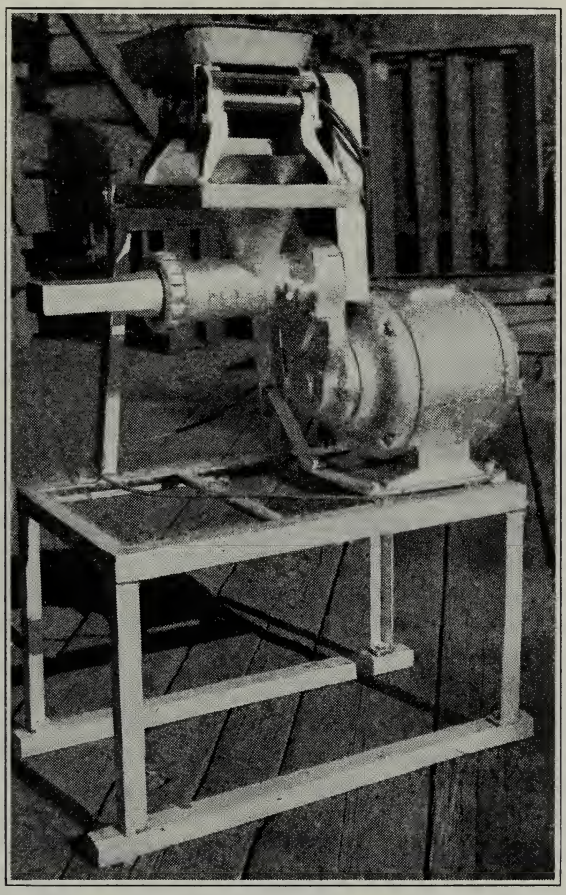

Fig. 7.—Small dried-fruit pitter (upper) and dried-fruit grinder (lower), for preparing date paste and similar products. (Courtesy of Elliott Machinery Company.)

A factory in Oakland, California, dehydrates dried apricots, peaches, and pitted prunes to a bone-dry (nearly water-free) state, grinds them to a powder or coarse meal, and packs them in friction-top cans. They are used by bakeries, and to some extent by others. They are excellent for use in bread.

The dehydration of clingstone peaches was first done commercially by Christie and Cruess at the University Farm, Davis, in 1919 (see

Bulletin 404, cited in footnote 37, p. 26). The procedure developed by them is now in commercial use for drying 35,000 to 50,000 tons (fresh basis) of clingstone peaches annually. The fruit is pitted by machine, lye-peeled, sulfured on wooden slat trays, dehydrated, binned to equalize the moisture, graded, sorted, and packed in boxes, cartons, or cellophane-wrapped packages. The product was popular in Holland, Denmark, Norway, and Sweden, before the war.

See *Commercial Fruit and Vegetable Products* (cited in footnote 15, p. 11) for information on standard methods of drying fruits and on processing and packing dried fruits. The Station has in preparation a circular by Mrak and Long on fruit drying and dried-fruit packing.[39a]

Figs.—At present the bulk of the dried-fig pack is converted into a heavy paste made by finely grinding sorted, selected figs. The paste is packed in paraffin-paper-lined boxes for use by the baking and confectionery industries. Fig paste has long been a standard commercial product, and the Station claims no credit for its development. This laboratory has, however, developed formulas for its use in candies, in a breakfast cereal, and in ice cream. See sections on use of fruits in these products.

Also, experiments have been conducted in this laboratory on the utilization of the lower grades in preparing fruit wines, and of cull figs in the manufacture of brandy. Some figs are used commercially in brandy manufacture, but like other fruit brandies, fig brandy is not in great demand because of the abundance of better-known distilled liquors.

In localities where figs do not dry well in the sun, the unpublished data of Christie and of Nichols show that dehydration may be used advantageously. Such figs are satisfactory for making into paste. Sulfuring is advisable if a light color is desired. The freshly sulfured fruit should be exposed to the sun for a few hours before dehydration in order to improve the color.

Cherries.—In 1920–1923 Christie and Cruess[40] conducted experiments on the drying of cherries and coöperated with commercial dehydrators in drying this fruit. A satisfactory procedure consisted in dipping the fruit a few seconds in dilute (0.5 per cent) sodium hydroxide, rinsing, spreading on wooden slat trays, sulfuring about ½ to 1 hour in the fumes of burning sulfur, and dehydrating at not above 150° F in a tunnel dehydrater.

[39a] Mrak, E. M., and J. D. Long. Methods and equipment for the sun-drying of fruits. California Agr. Exp. Sta. Cir 350. (In press.)

[40] Cruess, W. V., and A. W. Christie. Dehydration of fruits. California Agr. Exp. Sta. Bul. 330:1–30. 1921. (Out of print.)

Cruess, W. V., and A. W. Christie. Some factors of dehydration efficiency. California Agr. Exp. Sta. Bul. 337:1–23. 1921. (Out of print.)

The fruit "refreshes" well on soaking in water a few hours and cooking. Unless cherries are sulfured before drying, the color of black varieties becomes brown, and that of white ones darkens badly.

Pears.—The usual sun-dried pear is attractive in appearance but of rather poor flavor owing to its high sulfur dioxide content. Cruess and Christie (cited in footnote 40) found that pears prepared by halving, lye-peeling, exposing a relatively short time to sulfur dioxide fumes, and dehydrating at not above 150° F gave products of attractive appearance and excellent cooking quality. With modern mechanical peelers, it is possible that the price could be materially reduced and the quality improved.

Apples.—The drying of apples is a declining industry at present, although the present commercial product is satisfactory. Improvement in cold-storage practice has made fresh apples available throughout the year, and the export market is less extensive than formerly.

It is possible that "apple flakes," a confectionlike, sweetened, dried-apple pulp developed at the Utah Agricultural Experiment Station[41] in 1921, or a similar product devised more recently at the Washington Agricultural Experiment Station,[42] might be worthy of commercial trial. These products cook quickly and have been reported to possess a pronounced apple flavor. They may be used as confections or for cooking.

We believe, however, that other apple products, such as canned juice, canned sauce, and peeled, sliced apples, fresh or frozen, for bakers' use, have greater possibilities.

FRUITS IN CEREAL PRODUCTS

Man's most important source of energy is that of the cereal products, including bread, cakes, crackers, breakfast cereals, hot cakes, pies, and waffles. Some of these, such as pies, raisin bread, tarts, newtons, and Jelly rolls, contain fruits or fruit products. In England various tea cakes contain a great quantity of raisins and other fruits, and scones and buns are made with raisins or currants.

In Bread.—Raisin bread was established commercially many years ago by an intensive advertising and sales-service campaign by the then newly formed raisin growers' association. The new bread proved popular and utilized many thousands of tons of raisins. The early raisin breads were rich in raisins and therefore attractive in appearance and of distinctive and pleasing flavor. In a survey conducted in 1931 by J. H.

[41] Abell, T. H. Apple candy: a commercial use for cull apples. Utah Agr. Exp. Sta. Bul. 179:1–14. 1921.

[42] Gerritz, H. W., and J. L. St. John. Concentrated fruit and vegetable products: a new apple concentrate. Food Industries 11:369–70, 416–17. 1939.

Irish and W. V. Cruess,[43] it was found that most raisin breads then on the market were decidedly deficient in raisins; most contained less than 10 per cent by weight of raisins and some less than 5 per cent. The best raisin breads contained over 30 per cent of raisins. Figure 8 shows the appearance of two raisin breads from the survey.

While loaves made with very high content of raisins are not so light in texture nor of such large volume as the usual raisin loaf, they are much superior in flavor and in appearance of the cut slice. They retain their freshness for a long period owing to the invert sugar of the fruit, and are particularly desirable for toasting. We have no suggestions for

Fig. 8.—Samples from raisin-bread survey; on the left, satisfactory raisin content.

improving existing raisin breads and promoting the use of raisins in bread, other than coöperation of the raisin packers and distributors with bakers to increase the raisin content of commercial raisin breads to above 30 per cent. At present low prices, this would not add materially to the cost of the loaf. It would greatly improve quality and should correspondingly increase the use and markets for raisins. We would suggest that a few leading bakeries in each large urban area be induced to place such a bread on the market; if their venture proves profitable, other bakers will follow suit.

In England, currant buns and raisin scones are very popular. The bun contains a generous amount of Greek or Australian currant raisins (dried Zante currant grapes). We have similar products in America. The raisin scone, however, is not generally known in America. As served in restaurants and tea parlors in England, it appears to be made of baking-powder biscuit dough, to which is added seedless raisins, perhaps 25 per cent by weight. It is the English equivalent of the great American

[43] Irish, J. H., and W. V. Cruess. Raisin bread investigations. Bakers Weekly 71(6): 45–47. 1931.

doughnut, and is served with tea, Bovril, English "coffee," or other hot drinks, much as Americans serve coffee and doughnuts. It might prove popular in America if properly introduced by chain restaurants, cafeterias, and bakeries.

In 1929 Mrak and Cruess reported successful experiments made in coöperation with the Sperry Flour Company of San Francisco, and several bakeries in the Oakland–Berkeley area in making prune bread. Subsequently, in coöperation with L. B. Williams of the Dried Fruit Research Institute of San Francisco, one of the large chain-store organizations baked prune bread made according to the Station formula, and sold it one day a week ("prune-bread day"). Demand was excellent. Prune pulp made by sieving cooked prunes was added to the dough. The formula will be found in Bulletin 483 (cited in footnote 35, p. 23) but is subject to revision to suit the bakery routine.

Pitted, chopped prunes, if free of pieces of pit, may be incorporated in bread dough; also vacuum-dehydrated, bone-dry, powdered prunes may be so used, but are much more costly than the pulp or pitted prunes. Canners could supply canned prune pulp in no. 10 cans at low cost for use in prune bread; or bakers could prepare the pulp readily by cooking and sieving the dried prunes.

At one time figs were used in a bread. The figs were torn open by machinery, sorted on a belt, cut into pieces about ⅛ to ¼ inch in diameter and dusted with flour for sale to bakers. The bread was pleasing in appearance and flavor. It enjoyed a limited sale in California some twenty years ago. If supported by sustained sales and service effort, it might be made an important market for figs.

Apple bread has been made at various times. Apple purée, or unsweetened applesauce, or finely ground dried apples may be added to the dough. Owing to the light color of the apples, they are not very evident to the eye. The loaf is said to remain fresh for a considerably longer time than plain bread, and it toasts well.

In general, the less-acid fruits, such as raisins, prunes, and figs, appear better suited than the tart fruits, such as apricots, peaches, and apples, for use in bread.

Newtons.—Fig newtons, sweet pastry cookies stuffed with fig paste, are well known, low-priced, and popular. Ground figs (fig paste) are cooked to a heavy consistency with sugar and glucose or invert sirup and the paste is folded into the rolled-out newton dough; the dough is then cut to the desired length and baked in a continuous oven.

Prune pulp, apricot pulp, and other fruit pulps can be used in a similar manner. We found that prune pulp in newtons dried out rather

rapidly, and the newtons became soggy. If used within a few days after baking, they were satisfactory.

Fruit Products for Use in Pies.—With muscat raisins a rich and pleasing pie is obtained; with Thompson Seedless raisins the pie is rather characterless.

Canned water-pack Thompson Seedless grapes picked before they are fully ripe are a very good substitute for gooseberries in pies. Canned muscat grapes are used to some extent in pies.

Sieved prunes make an excellent open or crisscross pie of the pumpkin type. Bakers have found the formula given in Bulletin 483 (cited in footnote 35, p. 23) satisfactory.

We believe that the greatest possibility for increasing the use of fruits in pies is not in the commercial pie industry, but in the home—namely, in providing the housewife with canned fruits suitable for use in pies and at low cost. No one at present packs solid-pack, canned fruits for pie, in cans of suitable size for home use. The housewife must use fresh fruits in season, or dried fruits or relatively high-priced canned fruits in sirup. The customary no. 10 ("gallon") size can of pie fruit is packed for wholesale distribution to commercial bakers and is much too large for home use. A no. 2½ can is about the proper size for the home.

We have canned peaches sliced crosswise, not in the usual commercial crescent-shaped slices, solid-pack, and found them well received by Berkeley housewives. Slices of this type give a homemade appearance to the pie. The sliced fruit was steamed until partially cooked, canned hot, sealed, and processed a short time in boiling water. The fruit packed in this manner was preferred to that thickened with flour or tapioca starch and flavored with cinnamon and sugar. The housewives who coöperated in the experiments preferred to add their own thickening agent and flavoring.

Pears were packed successfully in similar fashion. A small amount of boiling water was added to fill the spaces.

Ripe, halved apricots were steamed and packed as outlined for the sliced peaches.

Prune pulp was canned and used in open pies. Fresh plums were canned whole as solid pack after steaming until soft.

Pitted, sour, water-pack, pie cherries are already available for home use. The Royal Anne (Napoleon) and Black Tartarian, the principal California varieties, are not much in favor for use in pie. Some Royal Annes have been pitted, artificially colored, and canned for use in pies. This is an expedient of doubtful value.

Of the other California fruits, the fig is one of the most satisfactory for use in pie. The fruit may be sorted; the softer fruit set aside for pie

use, washed, steamed thoroughly, canned in solid-pack scalding hot, sealed, and processed about 1½ hours in boiling water in no. 2½ cans or 2 hours in no. 10 cans. The housewife or baker adds sugar, thickener if needed, and uses the product in either open or covered pies. The varieties with prominent seeds such as the Calimyrna are preferred.

Bakers find frozen-pack fruits excellent for use in pies. Bulk-packed berries and pitted sour cherries, in particular, are so used in important amounts. Perhaps a market could be developed for small packages of frozen-pack berries for use in homemade pies. For this purpose they could be packed in cartons or paraffined cups as a 5:1 pack instead of the usual 2 or 3:1. Price is, of course, an obstacle in this instance.

Apricots and peaches for bakers' use should be dipped in dilute sulfur dioxide solution before freezing in order to prevent darkening.

Pears in any form have not proved popular for use in pies. In most canneries the pie grade of pears are ground and run into the sewer as a waste product.

Water-pack and solid-pack canned fruits in no. 2½ cans for household use are not only useful in pies but also in preparing jams, preserves, butters, and jellies.

Prepared Fresh Fruits for Bakers' Use.—At one time commercial pie bakeries used chiefly canned apples or fresh apples prepared on the premises for use in pies. At present much of the bakers' needs for pie apples is supplied by sliced fresh apples prepared in factories devoted to their production. As the publication on this subject by Mrak and Joslyn[44] is not readily available, the following details are given.

1. A sodium bisulfite solution testing about 3,000 to 4,000 p.p.m. sulfur dioxide is prepared by adding about 1¼ pounds of C. P. sodium bisulfite to 20 gallons of water. A sulfur dioxide solution of about 4,000 p.p.m. can also be used. Two per cent salt may also be added if desired.

2. Paraffined wood, aluminum, stainless steel, or block-tinned equipment should be used for handling the solutions and fruit. Iron and copper must be avoided.

3. The apples are peeled, cored, and discharged into the solution. They are then removed, sorted, and trimmed, sliced or quartered, and discharged into the fresh solution.

4. The prepared fruit is exposed to the fresh solution for not less than 2 nor over 5 minutes. As the solution becomes weaker, the length of treatment is increased.

[44] Mrak, E. M., and M. A. Joslyn. Investigations on the use of sulfurous acid and sulfites in the preparation of fresh fruits and frozen fruits for bakers' use. Fruit Products Journal 12:135–40. 1933.

5. The solution is kept up to strength by adding more sulfur dioxide or bisulfite as necessary and occasionally replacing the solution with a freshly prepared one. The strength of the solution can be checked and controlled by frequent titration with standard iodine. This is not necessary unless rigid control is essential. Details of this testing procedure will be sent upon request.

6. The treated fruit is drained and packed in paraffin-paper-lined boxes. It should be delivered to bakers and other users promptly.

Peaches, pears, and apricots may be handled in similar manner.

Fruit Breakfast Cereals.—H. M. Reed, formerly of this laboratory, reported in 1929[45] on a successful formula for a dried-fruit cereal. Since his paper is not easily available, the more important details will be given briefly.

The formula for preparation of one such product is as follows:

7¼ pounds whole-wheat flour
14½ pounds white flour
1 pound baking powder
1 pound salt
2½ pounds nonrancidifying solid fat
72½ pounds prune pulp of about 73 per cent moisture

The ingredients were mixed into a dough; quickly formed into small loaves; placed in bread pans greased with a nonrancidifying fat; baked in a slow oven at about 410° F to avoid scorching and to cook through. The loaves were then sliced and the slices dried bone-dry on trays in a dehydrater. These were then coarsely crushed, screened to uniform size like Grapenuts, toasted a short time at 300 °, and packed in parchment-lined, paraffin-wrapped cartons. The product resembles Grapenuts in color and appearance and has a pronounced prune flavor. It is served in the same manner as any dry cereal.

Cruess and Irish[46] reported that the following formula gave a product that is not so hard and dense as that given by the Reed formula:

100 parts finely ground dried fruit
100 parts Cerelose or other corn sugar
50 parts wheat bran
100 parts whole-wheat flour
3 parts salt
4 parts baking powder.

All ingredients except the baking powder were mixed with water to give the desired consistency. Then the baking powder was mixed in

[45] Reed, H. M. A new fruit cereal. Fruit Products Journal 8(10):7–9. 1929.

[46] Cruess, W. V., and J. H. Irish. The use of fruits in cereals. Fruit Products Journal 12:302–3. 1933.

quickly and the dough formed into loaves. These were dusted with whole-wheat flour; placed in pans greased with nonrancidifying fat and baked at about 410° F. The loaves were then sliced and treated as described in the Reed procedure.

A third procedure described by Cruess and Irish was as follows:

100 parts whole-wheat flour
100 parts ground dried fruit
25–50 parts bran
6 parts baking powder
3 parts salt
Water to make a stiff dough

The dough was rolled on a slab or smooth board surface to about $\frac{1}{32}$ inch in thickness and dusted with flour. The thin sheet of dough was quickly cut into small rectangular pieces of about the size of Post Toasties and baked in a quick oven to a golden brown. The baking powder raises the "flakes" somewhat and makes them rather crumbly in texture. This product would probably lend itself well to continuous and automatic factory procedure.

Attempts were also made to prepare flakes by dropping a thin batter of fruit pulp, flour, baking power, and other ingredients on a hot metal surface but without very marked success. Sticking and scorching were the main difficulties. Possibly these could be overcome with commercial-scale equipment. At present, date flakes are made commercially in Beaumont in Riverside County by drying a thin layer of date paste on a hot roll.

FRUIT SAUCES

At the present time, applesauce is the only canned fruit sauce available to the housewife and to eating establishments. Our experiments have demonstrated that excellent canned and glass-packed sauces can be made from other fruits.[47]

The procedure recommended for apricots, pears, and peaches is as follows: The fruits are prepared as for canning as halves, then ground coarsely. One part of sugar is added to about 6 of fruit. The fruit is then heated to boiling, canned, sealed hot, processed a short time at 212° F, and cooled thoroughly. If the product is overcooked or cooled insuffi-

[47] Cruess, W. V. Utilization of surplus peaches and pears. Canning Age 12:457–64, 512–15. 1931.
Marsh, G. L., and W. V. Cruess. Experiments on the utilization of surplus apricots. Fruit Products Journal 11:334–35. 1932.
Cruess, W. V. Canned crushed peaches. Fruit Products Journal 15:328. 1936.
Cruess, W. V. The utilization of surplus plums. Fruit Products Journal 18:72–74, 89, 91, 101–5. 1938.
Cruess, W. V. Commercial fig products. Fruit Products Journal 17:337–39, 343, 368, 369, 377; 1937; 18:39–42. 1938.

ciently, it is apt to be too soft. An alternative procedure is to pack the ground fruit with 1 volume of 40° Brix cane-sugar sirup to 3 parts by volume of the fruit; exhaust 12–15 minutes at 200° F, seal, process at 212° until cooked to the desired extent, and cool thoroughly.

Figs are stemmed, washed, coarsely ground or sliced, mixed with 1 part of sugar to about 4 of fruit, heated to boiling, canned hot, sealed, and processed at the boiling point about 1 hour (not less, in order to avoid spoilage), and cooled well.

Plums were made into a sauce by adding water to barely cover in a kettle, adding 1 part of sugar to 4 of the mixture, cooking until soft, canning scalding hot, processing a short time at the boiling point, and cooling. Enameled type-L cans should be used for red plums.

These various sauces are not jams to be used as spreads on bread. They are tart to mildly tart or only moderately sweet in taste and are to be served as breakfast dishes and as light desserts. Those made from figs, pears, peaches, and apricots are very useful in whips, gelatin desserts, open pies, homemade ice cream, and puddings.

For further details see the references cited in footnote 47.

SIEVED FRUITS OR FRUIT PURÉES

Sieved fruits are in considerable demand in canned form as foods for infants. These products may be made from the fresh fruits by first preparing them as for canning in the usual manner. They are then steamed until soft and passed through a Sep-ro-siv type of apparatus (tomato-juicer) or through a tomato-pulper (Cyclone). The hot purée may be canned, sealed, and processed in boiling water until heated completely through to not less than 190° F. Figs require a longer period at the boiling point because their low acidity renders them very difficult to sterilize. There is danger of botulinus poisoning from insufficiently sterilized fig products. Acidification with about 0.5 per cent of citric acid before canning is a great protection against such danger.

Dried prunes may be cooked with water until soft; then passed through a tomato-pulper of sturdy construction; and the purée canned as described for other fruits. Such prunes are of very heavy consistency and require sweetening for the average adult. In the home they may be diluted with water and lightly sweetened for serving as breakfast drinks. They are also useful in various frozen desserts, puddings, gelatin desserts, whips, and similar desserts.

At present sieved fruits are available to the housewife only in very small cans or jars for infant feeding. Perhaps there would be a market for these products in larger cans and jars for use in the home in the

various manners indicated above. The canning procedure is very simple and inexpensive and fruit of the smaller sizes could be used. Therefore, the retail price should be low.

BREAKFAST FRUITS

For many years canned and glass-packed "breakfast figs" have been on the market. Most of the Kadota figs canned in this state and some of the Texas variety are packed in this form; that is, in a light sirup for use as a breakfast dish. Recently other California fruits have appeared on the market under this same title; namely, as breakfast apricots, peaches, and pears.

The fruit may be packed in the usual commercial manner in a light sirup; although, in order to set it off as a distinctly different product, the fruit may be sliced or packed as a sauce as previously described. Except for figs, the sirup should be approximately 20° to 25° Brix at time of canning; figs require a sirup of about 50° in order to "bring out" their characteristic flavor.

Diced pears and peaches have been packed commercially in this manner, but did not become popular.

Mixed fruits such as canned fruit cocktail are excellent as breakfast dishes and for light desserts. For breakfast use, the mixed fruits should be packed in somewhat lighter sirup than is used for the usual fruit cocktail. The Maraschino cherries may be omitted in the breakfast mix and the cost thereby considerably reduced. For breakfast use, we have found that the addition of some grapefruit juice to the sirup adds to the flavor in a pleasing manner.

COFFEE SUBSTITUTES

For many years various coffee substitutes made from dried figs or prunes or both admixed have been on the American market. The chopped dried fruits may be roasted and coarsely ground for use in making breakfast beverages free of caffein. Care must be taken in roasting in order not to char the products unduly. Roasting should be conducted with automatic control of temperature and time. Suitable controllers are available.

If a roast low in sugar is desired, the sugars may be extracted from the chopped fruit with hot water, the fruit then drained, dehydrated, and roasted.

There are several fruitless coffee substitutes and decaffeinated coffees of pleasing character available at relatively low price. Consequently we doubt whether a very great potential market exists for fruit "coffees."

VINEGAR

Vinegars have been made experimentally by commercial vinegar factories and by various research laboratories from many kinds of fruits. In America, however, the average consumer is accustomed to use apple vinegar chiefly; those of southern European origin prefer wine vinegar. Vinegar is a low-priced product and is used in limited quantities. That is, price is of no particular importance in vinegar consumption as the human organism's capacity for this product is definitely limited. Cull apples and apple waste from apple dryers are the usual raw materials and are worth only $1.50 to $3.00 a ton for vinegar making. We believe, except for making small amounts of vinegar in the home, that the use of other fruits for vinegar would be decidedly unprofitable. For details of procedure see Circular 332.[48]

PICKLED AND SPICED FRUITS

Figs and peaches and to a lesser extent a few other fruits are packed in glass or canned in a heavy vinegar sirup as "fruit pickles" or in a lighter sirup as "spiced fruits."

In the preparation of fruit pickles in heavy sirup, the fruit prepared as for canning is cooked in a spiced sirup in jelly kettles to a heavy preserve, packed in glass, sealed, and pasteurized in the containers. The following formula may be used or modified to suit the desires of the operator:

20 gallons water
12 ounces dry gingerroot
14 ounces whole cloves
18 ounces stick cinnamon
3 gallons 40-grain cider vinegar
125–130 pounds sugar

The spices are placed in cheesecloth bags. The fruit is cooked in the sirup to a preserve consistency, that is, to about 60 per cent sugar. It is allowed to stand overnight to absorb sirup, then the spices are removed, and the fruit is packed in vacuum-sealed preserve jars and pasteurized at 175°–180° F for 30 minutes. If the fruit tends to shrivel during cooking, it is blanched until tender in boiling water before cooking in the sirup. Very tender fruits such as apricots may have to be placed in a heavier sirup and cooked a shorter time. Some packers use the progressive method of cooking, in which the fruit is cooked a short time on each of several successive days in sirup increased in density each day by addition of sugar.

[48] Cruess, W. V., and M. A. Joslyn. Home and farm preparation of vinegar. California Agr. Exp. Sta. Cir. 332:1–29. 1934.

Spiced fruits may be considered those canned or glass-packed directly in a medium to medium-heavy, spiced, vinegar sirup. One procedure consists in proceeding exactly as in the preparing of fruit pickles described in the preceding paragraph to the point where the fruit is to be added; except that only sufficient sugar is used to give a sirup of 40° Brix.

Instead of cooking the fruit in kettles in the sirup, it is packed in cans of resistant tin plate such as type-L cans; the spiced vinegar sirup is added; and the cans exhausted in the usual manner, sealed, and processed until the fruit is of desired texture. The time required will vary greatly with the variety of fruit and whether it is packed whole or in halves. A few pieces of cinnamon and cloves may be added to each package, if desired, for the sake of appearance. Small cling peaches and small pears are peeled and canned whole. In order to facilitate sirup penetration, cling peaches should be cut to the pit with a knife or a cut made around the pit with a pitting spoon. Apricots, plums, figs, and cherries are canned whole. Of California fruits, figs, cling peaches, and apricots appear to be best suited.

Pickled and spiced fruits are used as relishes or appetizers and in salads.

FRUIT WINES

Wines made from grapes and hard cider made from apples are the principal fruit wines throughout the countries of the temperate zones. On the other hand, wines are made commercially in limited quantities from berries, cherries, oranges, and pears; and dried figs and raisins have been used for homemade wines. At present the market is well supplied with grape wines and hard cider. Berries are not produced in surplus in California. Because of these conditions, we doubt whether other fruit wines made to sell at prices competitive with those of grape wines and hard cider would be profitable or salable in appreciable quantities. On the other hand, perhaps a moderate demand could be created for fruit wines of the dessert or cordial type.

Governmental Regulations.—All alcoholic-beverage industries are under strict state and federal control. No fermented beverage may be made for sale until the necessary permits have been secured, and full, written approval given by the various alcoholic beverage control and tax units. Penalties for nonobservance are extremely severe; prison sentences are not uncommon for violations. For specific information, apply to the State Liquor Control Board, Sacramento, and to the nearest office of the Alcohol Tax Unit of the United States Bureau of Internal Revenue.

Grape Wines.—There are many books on wine making, the best of which are listed at the end of Chapter XXX of *Commercial Fruit and*

Vegetable Products (cited in footnote 15, p. 11). Bulletin 639[49] discusses the production of table wines and supersedes the dry-wine section of Extension Circular 88,[50] now out of print. Bulletin 651[50a] discusses the production of dessert wines and supersedes the corresponding section of Extension Circular 88. A description and discussion of commercial wines and methods of production will also be found in *Principles and Practice of Wine Making*.[51] Much information can also be secured from various journals.[52]

Hard Cider.—Hard ciders are of several types: (*a*) natural unfortified, (*b*) sugared unfortified, (*c*) fortified, and (*d*) sparkling. The first-named may be made and sold free of internal-revenue tax. The others are termed "apple wines" and are subject to the respective state and federal wine taxes and regulations.

In preparing natural hard cider, we have found that it is necessary to apply sound wine-making practices. Selected pure yeast and a moderate addition of sulfur dioxide (100–125 p.p.m.) should be used. Otherwise the product is apt to be diseased and vinegar-sour. Commercial producers find that the fermented product should be filtered brilliantly clear, bottled, and pasteurized at 140°–150° F in the bottles. Prepared in this manner, it is ready to use within a month after crushing and keeps indefinitely. If stored in barrels as is grape wine, it is apt to become infected with spoilage bacteria that cause it to sour and become "mousey."

Fortified apple wines are made in about the same manner as fortified grape wines, as described by Cruess (references in footnote 15, p. 11; and footnote 51). The best fortified commercial cider that we have examined was made by fortifying slightly fermented apple juice with apple brandy of high quality to about 20.5 per cent alcohol. The brandy may be made from cull apples, peels, and cores. In the production of fortified wines of all kinds, the rules given by the Bureau of Internal Revenue[53] must be followed. Braskat[54] has recently given a good description of the production of apple and other fruit wines in the Pacific Northwest.

[49] Amerine, M. A., and M. A. Joslyn. Commercial production of table wines. California Agr. Exp. Sta. Bul. 639:1–143. 1940.

[50] Joslyn, M. A., and W. V. Cruess. Elements of wine making. California Agr. Exp. Sta. Cir. 88:1–64. (Out of print.)

[50a] Joslyn, M. A., and M. A. Amerine. Commercial production of dessert wines. California Agr. Exp. Sta. Bul. 651:1–186. 1941.

[51] Cruess, W. V. Principles and practice of wine making. vi + 212 p. Avi Publishing Co., Inc., New York, N. Y. 1934.

[52] *Fruit Products Journal*, Avi Publishing Co., Inc., New York, N. Y.; *Wine Review*, San Francisco, California; *Wines and Vines*, San Francisco, California.

[53] United States Bureau of Internal Revenue. Regulation No. 7 relative to the production, fortification, tax payment, etc., of wine. Federal Register 2:2467–2516. 1937. Also issued as a reprint. 188 p. 1937.

[54] Braskat, Norman, and H. A. Quinn. Apple wine. Wine Review 8(2):6–8, 26–27. 1940.

Braskat, Norman. Fruit wines. Wine Review 7(12):8, 26. 1939.

Sparkling cider is usually made by the same methods as are in use for sparkling wines. See Bulletin 639 (cited in footnote 49), and the book cited in footnote 51 (p. 42).

Perry.—In the preparation of perry, or fermented pear "cider," we have found the procedure used for hard cider satisfactory. In brief it was as follows: hard-ripe pears were crushed and pressed in apple-juice equipment. Soft-ripe fruit cannot be pressed successfully. To the juice was added 100–125 p.p.m. of sulfur dioxide in the form of sodium bisulfite ($NaHSO_3$), and a starter of 3 per cent by volume of active pure yeast in sterilized fruit juice. After fermentation was complete, the new perry was allowed to settle several days. It was then filtered and aged several months in oak before bottling.

Berry Wines.—In preparing raspberry and Logan, Young, and Boysen blackberry wines, the fruits were crushed coarsely; given an addition of 125–150 p.p.m. of sulfur dioxide, a starter of pure yeast, fermented until soft (2–4 days), pressed, sweetened with cane sugar to bring alcohol × 2 + residual sugar to an amount equal to an original 22°–23° Brix for table wines, and to 28°–30° Brix for dessert wines. Fermentation then proceeded to completion. The new wines were then allowed to settle, were racked, filtered, and aged in contact with oak. Sugar addition as indicated is necessary because these fruits are lacking in it. We are opposed to the excessive watering of such wines as is done so commonly in commercial practice. If the ripe California fruits are used, no water should be added. Some unfermented sugar should remain in the dessert wines in order to give proper balance.

Cherry Wines.—Ripe black cherries should be used. It is desirable that the pits be removed. The fruit is crushed, sulfur dioxide added as described for berries, and the fruit fermented 3 to 4 days with pure yeast. It is then pressed and treated as outlined for berries.

Berry Cordials.—Berry juices are made into cordials by addition of sugar and high-proof brandy. Special federal permission is required and the tax is very high. Berry-wine and other fruit-wine production in Europe is well described by Kroemer and Krumholz.[55]

Citrus Wines.—Some orange wine similar to sherry, and some grapefruit wine have been made commercially. The sherry-type wine may be made by fortifying with high-proof brandy the fresh juice, or that which has been partially fermented by controlled pure-yeast fermentation; and then settling, racking, filtering, and aging in the wood until of desired flavor. Unfortunately, excessive darkening and undesirable changes in flavor are apt to occur. Mild decolorizing of orange wine with vegetable

[55] Kroemer, K., and G. Krumholz. Obst- und Beerenweine. 292 p. Serger und Hempel, Braunschweig, Germany. 1932.

decolorizing carbon will prevent these changes, according to Von Loesecke, Mottern, and Pulley.[56]

Orange juice is an excellent medium for alcoholic fermentation, and consequently high alcohol content may be attained by its fermentation. In experiments in this laboratory, orange wines of 18 to 19 per cent alcohol content have been attained by adding about 5 per cent of cane sugar at intervals of 2 to 3 days during fermentation. Some excess of sugar may be left to improve the flavor.

Wines of alcohol content corresponding to that of grape table wines (11.0–13.5 per cent) can be made by fermentation of orange juice, and grapefruit juice sweetened to 20°–24° Brix; and by usual cellar treatment thereafter. The darkening problem and undesirable flavor changes are problems here as with the fortified wines. Most consumers prefer slightly sweet citrus wines to those sugar-free. Grapefruit wine is on the average superior to the orange in flavor and color.

Dried-Fruit Wines.—Infusions may be made from dried fruits by hot extraction with several changes of water, and fermentation of the infusion with pure yeast. Or the dried fruits may be covered with cold water, fermented with added yeast until soft, and pressed, and the resulting infusion fermented to completion.

Such "wines" however, are very poor substitutes for fresh-fruit wines, and should be used only for distillation for brandy.

FRUIT BRANDIES

In France and most other Mediterranean countries, grape brandy and certain fruit brandies, such as Calvados (a famous French apple brandy), Kirsch (cherry brandy), and arrack (date brandy), are more generally used than is whiskey; in the United States, the British Isles, and northern Europe, the reverse is true. Perhaps with proper advertising of high-quality fruit brandies, some increase in their consumption could be attained.

In small-scale tests and by use of a very small registered experimental still, we have made small quantities of plum, peach, apple, and pear brandies from the fresh fruits, and prune, fig, and date brandies from the dried. The fresh fruits were crushed, fermented with pure yeast and sulfur dioxide (100 p.p.m.), pressed, and the wine distilled to 130–140 proof; the distillate diluted to 100 proof, and aged in bottles in contact with oak shavings. The dried fruits were covered with water and then handled as described for the fresh.

[56] Loesecke, H. W. von, H. H. Mottern, and G. N. Pulley. Wines, brandies and cordials from citrus fruits. Industrial and Engineering Chemistry, industrial edition 28:1224–29. 1936.

The amounts made were altogether too small to secure accurate data on yields, but the flavor and bouquet of the aged brandies were of interest. The best brandies were those in which considerable of the "heads" and "tails" (aldehydes and fusel oils) of the distillation were retained. Those distilled to a nearly neutral brandy developed very little character. On the other hand, too much "heads" or "tails" will give a harsh, disagreeable product.

The details of factory design and equipment, government regulations and taxes, aging, and other details are beyond the scope of this circular. For further information see books[57] on the subject and Bulletin 652.[57a]

In general it may be said that the equipment needed for a brandy distillery is costly, the federal regulations very strict; the taxes very high, and the manufacture of high-quality brandies a difficult art. In addition, the product should be aged slowly in the wood for at least three years; therefore, heavy capital outlay is required. For these reasons, fruit-brandy production should be undertaken only by those who are well financed and who have or can secure experienced personnel.

VALUE OF FRUITS IN THE DIET

Fruits are very valuable in the diet, and most Americans could use more fruits and fruit products with benefit to health. They provide valuable vitamins, particularly C (the antiscorbutic or antiscurvy vitamin), G (riboflavin) of great dietetic importance, A (the "anti-infective" vitamin), and some B_1 (the antineuritic vitamin). Most fruits, on digestion, exert a marked basic reaction in the body, and thus counteract the acid residues of some other foods. Some fruits, particularly the stone fruits, are valuable in combatting anemia. Most are valuable sources of important minerals; and most fruits exert a mild laxative action, owing to the bulk effect or to the presence of laxative substances.

Those who wish to obtain specific information on this and related subjects concerning human nutrition may consult any authoritative book on nutrition.[58] The 1939 United States Department of Agriculture Yearbook is an excellent reference on the subject.

[57] Hirstein, K. M., and T. C. Gregory. Wines and liquors. xii + 360 p. D. van Nostrand Co., New York, N. Y. 1935.

Hirsch, I. Manufacture of whiskey, brandy and cordials. xvii + 136 p. Sherman Engraving Co., Newark, N. J. 1934.

[57a] Joslyn, M. A., and M. A. Amerine. Commercial production of brandy. California Agr. Exp. Sta. Bul. 652:1–80. 1941.

[58] Sherman, H. C. The chemistry of food and nutrition. 640 p. The Macmillan Company, New York, N. Y. 1938.

McCollum, E. V. The newer knowledge of nutrition. 5th ed. 701 p. The Macmillan Company, New York, N. Y. 1939.

United States Department of Agriculture. Food and life, U. S. Dept. Agr. Yearbook 1939. xv + 1165 p. 1939. For sale by Superintendent of Documents, Washington, D. C., for $1.50.

BY-PRODUCTS

The preceding sections have dealt chiefly with the utilization of fruits of edible quality. In addition, there are often large quantities of certain fruits unsuitable for food purposes and of waste fruit materials such as fruit pits, pomace (press cake), still slops, peels, and cores. Some of these cull fruits and waste products are utilized in part; others are discarded.

Fig. 9.—Grape pomace mixed with lime, for use as a fertilizer.

For example, grape pomace is often used as a low-grade fertilizer. See figure 9.

Space will not permit a detailed presentation of the manufacture of various by-products from fruit wastes. The more important products will be discussed briefly, and the general procedures and sources of information will be indicated.

Industrial Alcohol.—The Station receives many inquiries from growers, promoters, and fruit processors for information on establishing "power" alcohol factories, and the production of "power" alcohol. A great deal of ill-advised, promotional literature has appeared on the subject, and a number of attempts have been made to persuade fruit growers to invest in such plants.

From a consideration of possible yields and returns, the utilization of fruits for industrial alcohol, including that for possible admixture with gasoline, does not appear inviting. A very useful publication[59] has recently appeared on the subject of alcohol and other motor fuels from farm products. The authors, Jacobs and Newton, estimate the approximate yields of alcohol from various fruits as shown in table 2. We have in addition calculated the value of the alcohol from 1 ton of each fruit at 30 cents a gallon.

Jacobs and Newton call attention to the fact that "power" alcohol (anhydrous 100 per cent, 200-proof ethyl alcohol) from fruits, potatoes,

TABLE 2

APPROXIMATE COMMERCIAL YIELDS OF 99.5 PER CENT ALCOHOL FROM ONE TON OF VARIOUS FRUITS

Fruit	Average alcohol yield per ton of fruit*	Value at 30 cents per gallon†
	gallons	*dollars*
Apples, average fresh	14.4	4.32
Apricots, fresh	13.6	4.08
Dates, dry	79.0	23.70
Figs, fresh	21.0	6.30
Figs, dry	59.0	17.70
Grapes, eastern	15.1	4.53
Grapes, California	23.0†	6.90
Peaches, fresh	11.5	3.45
Pears	11.5	3.45
Plums	10.9	3.27
Prunes, dry	72.0	21.60
Raisins	81.4	24.42

* From: Jacobs, P. B., and H. P. Newton. Motor fuels from farm products. U. S. Dept. Agr. Misc. Pub. 327:1–129. 1938.

† Estimate by present authors.

and other crops must compete with that made from molasses, a very low-priced product. Table 3 gives their estimated costs of 100 gallons of alcohol from various raw materials.

To these costs must be added sales costs and overhead costs such as taxes, insurance, depreciation, and office expense. Ash[60] of the California Packing Corporation estimates the cost of making alcohol from a fruit at not less than 15 cents a gallon exclusive of cost of fruit. But accepting the estimates given by Jacobs and Newton, it can be seen that at a good price of 30 cents a gallon the manufacturer would lose 11.41 cents on each gallon of alcohol made from apples or about $1.63 for each ton, assuming he pays $5.00 a ton for the raw material.

[59] Jacobs, P. B., and H. P. Newton. Motor fuels from farm products. U. S. Dept. Agr. Misc. Pub. 327:1–129. 1938.

[60] Ash, Chas. Personal communication.

Cull dried fruits unfit for any other purpose appear somewhat more practicable than the fresh as sources of alcohol. Thus, at 30 cents a gallon for alcohol, raisins would appear to barely return the manufacturer his costs, if he pays $20.00 a ton for the raw material.

The market for alcohol for general industrial use (not for power purposes) in varnishes, for other solvent purposes, and as a base for preparation of other industrial compounds is well supplied at present with alcohol from molasses. There is, therefore, no present need for use of more expensive raw materials. In addition, alcohol can be made cheaply from petroleum products, or from acetylene made from lime and coal, or from wood waste.

TABLE 3

COMPARISON OF COSTS OF ALCOHOL FROM VARIOUS RAW MATERIALS*

Raw material	Price of raw material per ton	Cost of raw material for 100 gallons of alcohol	Probable manufacturing cost per 100 gallons of alcohol	By-product credits per 100 gallons of alcohol	Net cost of 100 gallons of alcohol	Net cost per gallon
	dollars	*dollars*	*dollars*	*dollars*	*dollars*	*cents*
Molasses	8.50	12.24	8.00	1.90	18.34	18.34
Corn	20.00	23.80	10.80	5.91	28.69	28.69
Potatoes, cull	10.00	43.70	11.15	4.32	50.53	50.53
Apples	5.00	35.00	9.50	3.09	41.41	41.41
Raisins	20.00	22.80	9.00	2.25	29.55	29.55

* From: Jacobs, P. B., and H. P. Newton. Motor fuels from farm products. U. S. Dept. Agr. Misc. Pub. 327:1–129. 1938.

Jacobs and Newton estimate the cost of an alcohol factory to produce 2,500 gallons of alcohol daily at $200,000, and one for 10,000 gallons daily at $575,000.

Stock Feeds.—Some agricultural wastes are now used for stock feed. Among these are dried citrus-fruit peels, dried apple pomace, dried grape pomace, cull raisins, cull dried prunes, and cull dried figs. Some surplus dried fruits of edible quality are also utilized, after suitable denaturing for human consumption. Grape pomace, apple pomace, and other fruit wastes are dried for stock feed in rotary drum driers heated directly by the products of natural-gas combustion, or indirectly by steam pipes. See figure 10.

The Station has conducted animal feeding tests[61] with a number of

[61] Mead, S. W., and H. R. Guilbert. The digestibility of certain fruit by-products as determined for ruminants. I. Dried orange pulp and raisin pulp. California Agr. Exp. Sta. Bul. 409:1–11. 1926. (Out of print.)

Regan, W. M., and S. W. Mead. The value of orange pulp for milk production. California Agr. Exp. Sta. Bul. 427:1–16. 1927. (Out of Print.)

Miller, Robert F. Raisin by-products and bean screenings as feeds for fattening lambs. California Agr. Exp. Sta. Bul. 431:1–16. 1927. (Out of print.)

Mead, S. W., and H. R. Guilbert. The digestibility of certain fruit by-products as

fruit wastes. The reader is referred to these for further details. In most cases the fruit wastes were fed in dry form. The feeding value of most of them is somewhat less than that of barley; and most are decidedly low in protein content. Their principal value is as a source of carbohydrates. Some, such as prunes, furnish considerable vitamin A. Dried grape pomace from wineries was found to be only 30 to 40 per cent as valuable as rolled barley, and about 60 per cent as valuable as good hay for use as stock feed. This material has been much overrated by the industry.

One advantage in using waste fruits for animal feeding is that several

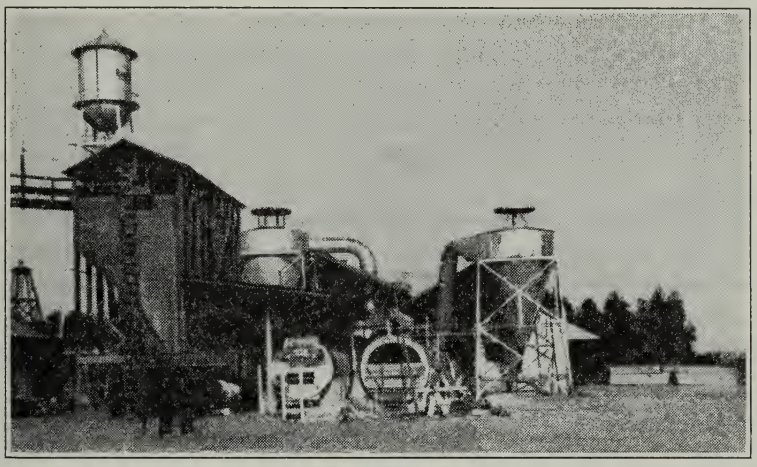

Fig. 10.—Plant for preparing dried stock feed from citrus peels.

pounds of the product is required to produce one of meat or one of dried milk. Consequently, human consumers have to eat perhaps only one sixth to one eighth as much of the end product (expressed on a dry basis) as of the fruits. Another advantage is that processing (drying) of the wastes is simple, and another is that the market is near at hand, namely, on the farm. Usually dairies, beef-steer feeding lots, or hog farms are near the source of the raw material; hence transportation costs are low.

Dried grapefruit refuse has been shown to be 82.8 per cent digestible, and dried orange refuse to be 80.8 per cent, according to research done

determined for ruminants. Part II. Dried pineapple pulp, dried lemon pulp, and dried olive pulp. California Agr. Exp. Sta. Bul. 439:1–11. 1927. (Out of print.)

Hughes, E. H. The feeding value of raisins and dairy by-products for growing and fattening swine. California Agr. Exp. Sta. Bul. 440:1–12. 1927. (Out of print.)

Regan, W. M., and G. E. Gordon. Fruits and fruit by-products as dairy cattle feeds. 2 pages. University of California Agricultural Extension Service, Berkeley, California. 1934.

Folger, A. H. The digestibility of ground prunes, winery pomace, avocado meal, asparagus butts, and fenugreek meal. California Agr. Exp. Sta. Bul. 635:1–11. 1940.

in Florida[62] on the value of citrus wastes. The digestibility figures place them in the class of high carbohydrate concentrates.

At the Virginia Agricultural Experiment Station[63] the digestibility of dried apple pomace from cider mills was determined, and found to be about 67 per cent. Some of this product is used in California in a mixed ration for dairy cattle by the Brown Dairy, Santa Cruz County.

Neal, Becker, and Arnold (cited in footnote 62) give the values shown in tables 4 and 5 for composition and coefficients of digestibility of various fruit products. From these tables one may compare the composition of the dried meals and their relative values as stock feeds as shown by their digestibilities. For a full discussion of this subject, see the various publications cited (footnotes 61 to 63). Unfortunately most of these are out of print; but they may be consulted in any university or first-class technical library; those published by the California Agricultural Experiment Station are available in many city and county libraries in the state.

Pit By-Products.—Apricot pits are collected from dry yards and canneries after drying in the sun and are cracked in plants in the Santa Clara Valley. The kernels are separated from the shells by brine flotation. Most of the kernels are shipped to eastern United States or to Europe for use in preparing sweet oil for pharmaceutical and other purposes, and imitation "bitter-almond" oil for use in flavoring extracts. The shells are carbonized in continuous destructive stills. See figure 11. Formerly the pyroligneous distillate, containing methyl alcohol, acetic acid, and tar, was recovered, and some of the constituents purified. At present, owing to other and cheaper sources of these compounds, the distillate is not utilized. The gaseous compounds are burned as fuel in the distillation. The carbonized shells are crushed, screened, and sold for mixing in poultry feeds, or are treated for use in casehardening of steels. They have high gas-absorbing power, consequently were in demand in the first World War for use in gas masks.

Apricot pits yield about 23–25 per cent of kernels; peach pits only about 7 per cent. It is very difficult to recover the kernels from peach pits. Consequently, they are dry distilled directly for carbon.

[62] Neal, W. M., R. B. Becker, and P. T. Dix Arnold. Dried grapefruit refuse—a valuable feed. Florida Agr. Exp. Sta. Press Bul. 466:1–2. 1934.

Neal, W. M., R. B. Becker, and P. T. Dix Arnold. The feeding value and nutritive properties of citrus by-products. Florida Agr. Exp. Sta. Bul. 275:1–26. 1935.

Pulley, G. N., and H. W. von Loesecke. Drying methods changes composition of grapefruit by-products. Food Industries 12(6):62–63, 100–1. 1940.

[63] Holdaway, W. C., W. B. Ellett, J. F. Eheart, and M. P. Miller. The importance of properly balanced rations in trials to determine digestibility as shown in experiments with dried apple pomace. Virginia Agr. Exp. Sta. Tech. Bul. 32:1–18. 1927.

Cherry pits may be used in the same manner as apricot pits, although those from brined cherries are said to be of little value.

The procedures generally followed in producing sweet oil and "bitter-

TABLE 4

COMPOSITION OF CERTAIN FRUIT BY-PRODUCTS*

Product	Dry matter	Crude protein	Crude fiber	N-free extract	Crude fat	Ash
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Orange pulp	87.50	7.70	7.81	66.96	1.68	3.35
Lemon pulp	92.90	6.39	15.00	65.24	1.23	5.04
Raisin pulp	88.68	9.58	19.32	45.57	10.54	3.67
Pineapple pulp	83.60	3.81	13.88	61.94	0.71	3.26
Olive pulp	92.02	5.91	36.45	31.54	15.63	2.49
Olive pulp (pitted)	95.11	13.99	19.27	31.04	27.39	3.43
Apple pomace	86.68	4.31	17.03	69.76	5.13	3.77
Grapefruit pomace	91.77	4.94	11.94	69.60	1.06	4.23
Winery pomace†	93.00	11.80	34.02	36.31	4.52	6.35

* All except winery pomace from: Neal, W. M., R. B. Becker, and P. T. Dix Arnold. The feeding value and nutritive properties of citrus by-products. Florida Agr. Exp. Sta. Bul. **275**:1–26. 1935.

† From: Cruess, W. V. (Unpublished data.)

TABLE 5

COEFFICIENTS OF DIGESTIBILITY OF FRUIT BY-PRODUCTS*

Product	Dry matter	Crude protein	Crude fiber	N-free extract	Crude fat
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Orange pulp	89.33	78.54	83.73	95.40	48.89
Lemon pulp	81.43	46.18	60.33	92.01	27.44
Raisin pulp	44.78	24.13	18.54	52.01	90.16
Pineapple pulp	74.56	20.75	69.62	79.75	Slight
Olive pulp	19.09	Slight	Slight	20.27	86.02
Apple pulp	67.00	37.00	54.00	80.00	32.00
Grapefruit pulp	82.80	24.83	71.52	92.43	79.37
Winery pomace†	27.30	16.10	27.10	23.00	71.60

* All except winery pomace from: Neal, W. M., R. B. Becker, and P. T. Dix Arnold. Florida Agr. Exp. Sta. Bul. **275**:1–26. 1935.

† From: Folger, A. H. The digestibility of ground prunes, winery pomace, avocado meal, asparagus butts, and fenugreek meal. California Agr. Exp. Sta. Bul. **635**:1–11. 1940.

almond" oil from fruit kernels are described by Cruess (cited in footnote 15, p. 11) and by Rabak.[64]

Grape Seeds.—The seeds resulting from the seeding of muscat raisins are mixed with water, and the adhering sugar-containing pulp fermented. High-proof brandy is recovered by distillation. The seeds are dried, crushed, and pressed for oil used in coating muscat raisins against

[64] Rabak, F. Peach, apricot and prune kernel as by-products of the fruit industry in the United States. U. S. Bureau of Plant Industry. Bul. **133**:7–34. 1908. (Out of print.)

sugaring and in other industrial processes. The press cake may be used as a low-grade stock feed in mixed rations. It is very high in crude fiber.

Seeds are separated from winery pomace in European countries by sifting and winnowing, and are used for fixed oil production. In experiments conducted in this laboratory,[65] seeds were separated from dried pomace by screening. Oil was extracted by trichloroethylene from the ground seeds. The seeds contained an average of about 10 per cent of oil.

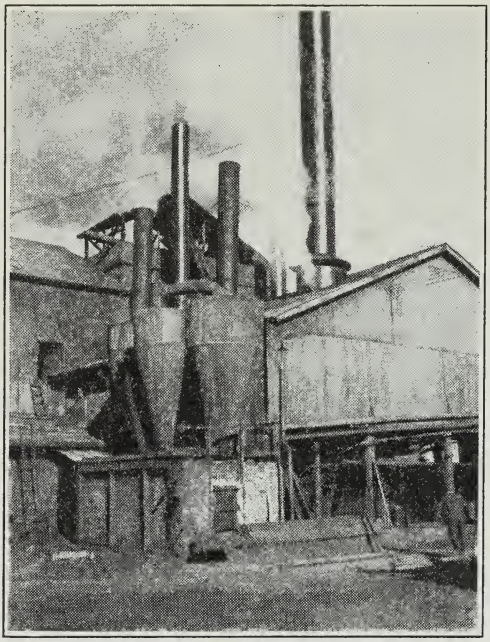

Fig. 11.—Fruit-pit by-products plant.

Tannin may be extracted from seeds from natural, dry-wine pomace; those from sweet-wine pomace are practically devoid of tannin because of previous extraction with water for recovery of alcohol.

Olive Pomace.—In Italy, France, and Spain, olive pomace is dehydrated and extracted with carbon disulfide, gasoline, or trichloroethylene.[66] The solvent is removed by distillation, and the residual oil sold for soap making, or refined for use as edible oil. In Bari, Italy, many factories are operated for the production of refined, edible oil from the pomace.

In California most of the pomace is utilized as fuel, although recently

[65] Cruess, W. V., and C. A. Weast. The utilization of pomace and still slops. Wine Review 7(2):10–14, 27. 1939.

[66] Cruess, W. V. Olives in Egypt and Italy. Fruit Products Journal 19:11–16, 25, 28. 1939.

two solvent-extraction plants have been established in the San Joaquin Valley.

Other By-products.—A number of the products discussed in previous sections, such as fruit vinegars, wines, sirups, brandies, juices, jelly juices, and others are in the nature of by-products if off-grade fruits and fruit wastes are used as raw materials.

Pectin and essential oils are made from citrus peels, and citric acid is made from the juice. Most of the surplus lemons of this state are so utilized with the purpose of removing them from the fresh-fruit market, regardless of the returns from the by-products. The enhanced value of the remaining fresh fruit is considered the main objective. The processes used have been outlined by Wilson (footnote 27, p. 20). See also Cruess (footnote 15, p. 11) and Poore.[67]

Pectin, as previously stated, is used in the manufacture of jellies, jams, and preserves. Nonfood uses are being investigated by several research laboratories. Citrus oils are used in soaps, cosmetics, and flavoring extracts.

Citric acid (see references in footnotes 15 and 27, p. 11 and 20) is an important lemon by-product. The California Fruit Growers' Exchange has been responsible for the establishment and development of the manufacture of this acid as well as of essential oil, and pectin from cull and surplus lemons.

At present severe competition exists between citric acid from lemons and that made synthetically from sugars by the use of certain molds. Citric acid is also made in Hawaii in considerable quantities from pineapple waste.

From the waste lees (sediment) from wine is recovered high-proof brandy for fortification of dessert wines, and cream of tartar, used in baking powder.

A very useful recent publication dealing with various aspects of the problem of utilization of various surplus crops is that of the United States Department of Agriculture.[68] on the survey for the Regional Research Laboratories. These laboratories, four in number, will be devoted to research on the utilization of surplus plant and animal agricultural products.

[67] Poore, H. D. Citrus pectin. U. S. Dept. Agr. Dept. Bul. 1323:1–19. 1925.

[68] Anonymous. Regional research laboratories, Department of Agriculture. 76th Congress, Senate Document 65:1–429. 1939.

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